THE EMOTIONAL ENHANCEMENT OF MEMORY:

ENCODING AND RETRIEVAL EFFECTS

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Abstract

The influence of emotion on memory and the role of encoding and retrieval effects were examined in a series of 10 experiments. Retrieval effects were examined in the first 3 experiments by investigating the success of different memory retrieval strategies. Positive emotional enhancement of recognition was found in traditional two-alternative forced-choice recognition and a task which encouraged a nonanalytic retrieval strategy. No emotional enhancement of memory was found in a task which encouraged an analytic retrieval strategy or when a Remember / Know / Guess judgement followed recognition. The paradigm was adapted to a within-participants design but emotional enhancements of recognition were no longer found. The next 7 experiments explored encoding effects with a paradigm investigating visual specificity of memory. Participants identified whether pictures were Same / Similar / New (SSN) in comparison to those shown at study. The findings from the SSN and Remember / Know / New paradigm were compared, with negative emotional enhancement of memory found in both. Negative and positive emotional enhancement of memory for specific visual details was found, with a central-peripheral trade-off in memory with negative emotion when objects were presented on congruent neutral backgrounds. Eye movements were recorded at encoding to examine attentional effects. Attentional narrowing was found on scenes with a negative object but no attentional effects were found with positive emotion. In the last 3 experiments associative memory, implicit memory, distinctiveness of emotional stimuli and warnings of emotion were measured and manipulated but could not account for the memory effects. Surprisingly, the emotional memory effects remained even when stimuli were blocked into emotional groups radically altering the distribution of visual attention. The implications of the results for choice of experimental stimuli, task instructions in experimental paradigms and the memory processes of encoding and retrieval are discussed.

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Chapter 1 – Introduction

General introduction to thesis

In this thesis I will examine the influence of emotion on memory by examining factors at the time of encoding and retrieving memories of emotional and non-emotional stimuli that have been presented in a controlled laboratory setting. To set this research into the context of existing theory and research findings I will provide an overview of the relevant scientific literature in three sections. Firstly, I will review the psychology of emotion by considering what emotions are, how they can be defined and the influence that has been demonstrated of emotion on different aspects of cognition. Secondly, I will consider the different methodologies which can be used to investigate emotions' effects on memory, how emotions and memory can be measured and manipulated and how different methods of research may impact on research findings of emotions' influence on memory. Lastly, I will review the specific literature investigating emotions' effects on memory, the different stages of the memory process that can be affected by emotion and the different types of memory which can be affected by emotion.

Section 1. The psychology (cognition) of emotion

Section 1.1. What are emotions?

Emotions are pervasive and fundamental experiences of human life which motivate us to pursue short and long term goals in our life. Emotions can have diverse effects on our behaviour which can be constructive or destructive; the fear of a dangerous situation could initiate a flight response which could save your life whereas, the grief of a person recently bereaved of a loved one could block their ability to function in everyday life. Historically, cognition and emotion have frequently been considered, and studied, as separate entities. However, modern research suggests that rather than being separate, cognition and emotion are intertwined and interdependent at both psychological and neural levels (see Fox, 2008 for a review).

There are different broad frameworks which have been used to study emotion and which emphasise different components of emotion and describe different levels of involvement of cognitive processes. In this thesis research will be discussed which takes a variety of perspectives on emotion, and may often draw from a variety of these theories to aid in the interpretation of research findings. Four broad approaches to investigating emotion are briefly described below:

i) <u>emotions are biologically given</u>: emotional systems have evolved to co-ordinate various body processes (including motor systems, energy, physiological reactions & cognitive processes) to solve immediate and urgent problems (e.g. Ekman, 1992). E.g. if threat is detected the emotion of fear would facilitate an appropriate flight reaction.

ii) <u>emotions are socially constructed</u>: emotions are culturally learned behaviours to help define the culture's values and assist members of the society in negotiating social roles. E.g. In North European & American societies where individualism is highly valued, anger is often seen as an acceptable way of asserting one's will, whereas in Asian societies where collectivism is highly valued, it may be seen as unacceptable as it indicates social disharmony (Kitayama, Markus, & Kurokawa, 2000).

iii) emotions are the result of perception of bodily changes: emotions occur as a result of a change in the environment (e.g. seeing a bear in the woods) leading to a variety of physiological changes (e.g. activation of brain's autonomic system and biochemical and hormonal changes in specific parts of the brain). The perception of these changes causes the emotional experience (Damasio, 1999; James, 1884; Lange, 1885).

iv) emotions are the result of cognitive appraisals: the way we evaluate or appraise the significance of events around us determines the type of emotion that is experienced. It is not the situation itself that produces an emotion, but how the situation is appraised in reference to current goals that produces an emotion (Arnold, 1960).

These four approaches to the study of emotion are not mutually exclusive or in competition with one another. The approach taken will depend on the experimental paradigm being used. It is, however, important to be aware of these different approaches because findings in one area may not necessarily generalize to another area and this may be due to the different definitions of emotion.

Section 1.1.1. How can emotions be defined?

The scientific examination of the psychology of emotion requires a systematic approach to be taken to a range of experiences which are inherently difficult to standardise and define. There is no general agreement in emotion science on how emotion should be defined and many theorists agree that each emotion consists of a number of different components, including subjective report, physiological response and cognitive appraisal (Fox, 2008). Nevertheless, in contemporary psychological research where emotions are often induced by the presentation of emotional and non-emotional stimuli to research participants, emotions have most often been defined along the dimensions of emotional arousal and emotional valence. It has been argued that the dimensional view of emotion is parsimonious in that the two primary dimensions of arousal and valence can define the entire spectrum of emotional behaviour, rather than assuming discrete and independent specific emotional states (e.g. fear, anger, joy) (see Bradley, Greenwald, Petry, & Lang, 1992). These bipolar factors of pleasantness and intensity have been found to account for most of the variability in judgements of the affective nature of text passages and map onto behavioural dimensions of direction (approach or avoidance) and vigour (i.e. mobilization) (see Bradley et al., 1992).

There are also researchers who examine the different influences of defined specific emotions, such as anger, fear, happiness, contentment, rather than by just defining emotion along two linear dimensions of arousal and valence. It has been argued that for a more complete understanding of the effects of emotion it is essential to take into account the differing motivations and problem-solving strategies associated with discrete emotions (Levine & Pizarro, 2006).

Section 1.1.2. Moods vs. emotions

In everyday language we more often discuss the moods we are experiencing than our emotions. There is no accepted agreement on the distinction between emotions and moods, but in general an emotion is a reaction to a particular situation or object that can be quite intense and leads to temporary changes in function and arousal whereas, a mood is a less intense experience which lasts for a longer period of time and is often more general. One view that is widely accepted is that moods are continually present and provide the emotional backdrop to our everyday life, and emotions are the disruptions superimposed onto this background (Davidson, 1994). It is sometimes unclear in psychological research whether a mood state or emotion is being investigated as a mixture of these may be activated in many studies (e.g. Dewhurst & Parry, 2000).

Section 1.1.3. Everyday emotions and clinical disorders of emotion

Up to this point the theories of emotion discussed have been of levels of everyday experiences of emotions, rather than the extreme levels which may occur in clinical disorders of emotion, such as clinical depression or anxiety. This is because there is a divide in the literature between theories considering normal emotions, and those considering emotional disorders. There has been an attempt to integrate the literature and provide a framework that incorporates theoretical explanations of everyday ‘normal’ emotions and the extreme levels of emotion experienced by people with clinical disorders by Power & Dalgleish (1997). However, in this thesis the emphasis is on investigating cognitive processes which are affected by emotion and therefore we will only consider theories of normal emotion in our interpretation and exploration of findings, rather than also trying to integrate theories of emotional disorders.

Section 1.2. What effects do emotions have on different aspects of cognition?

Emotions have been shown to affect early stages of cognition, such as perception and attention, as well as late stages of cognition, such as information-processing and memory. Research and theoretical findings concerning emotions' influence on attention and memory will be considered in detail in Section 3 of this introduction as these areas are directly relevant to this thesis. A brief overview of the influence of emotion on the cognitive processes of perception and information processing will be given here to provide some context to the investigations of emotions' influence on memory.

Section 1.2.2. An early stage of cognition: Perception

In the earliest stage of cognition, that of perceiving stimuli in the environment, one of the challenges is in deciding which information should be perceived and processed as it is not possible to process all of the information with which we are surrounded. As described above, one proposed function of emotion is to prioritise and demarcate the important information which should be perceived and processed, at the expense of irrelevant information.

Emotion has been shown to enhance early perceptual processing from neuroimaging studies (for a review see Vuilleumier, 2005) and behavioural consequences of this modulation of early visual processing have also been demonstrated. Presentation of a negative emotional cue (a fearful face) has been shown to increase the level of sensitivity to contrast in a simple visual stimulus (Phelps, Ling, & Carrasco, 2006). Further research has shown that emotion can both improve and impair early vision, by inducing a trade-off in visual processing and that this may benefit perceptual dimensions which are relevant for survival at the expense of those that are less relevant (Bocanegra & Zeelenberg, 2009).

Perception and attention are closely linked, although the exact nature of this relationship has been a matter of considerable debate. It has been argued that emotional information can only be identified after the allocation of spatial attention (Calvo & Nummenmaa, 2007), but it has also been argued that emotional information can be identified before the allocation of spatial attention (Kern, Libkuman, & Otani, 2005).

Section 1.2.3. Emotional information processing

In addition to influencing initial perception, emotion has been shown to have an influence on the processing of information. Positive and negative emotions have been shown to differentially affect a person's style of evaluating arguments; positive emotions tend to promote heuristic, creative and flexible modes of information processing, while negative emotions tend to promote a more analytic, data-driven mode of information processing (Levine & Pizarro, 2006). Bodenhausen, Kramer & Susser (1994) found that individuals who had been induced to feel happy rendered more stereotypic judgements than did those in a neutral mood, but that when motivation was sufficient they were able to overcome this influence of stereotypes on their judgements.

This change in information processing style brought about by emotion has been shown to affect the judgements that people make in attributing the cause of a person's behaviour. Forgas (1998) found that negative moods decreased the Fundamental Attribution Error, where people attribute the cause of a person's behaviour to dispositional personal factors within the person's control, even when there is strong evidence that the person's behaviour was due to external influences. In contrast, positive moods were found to increase this fundamental attribution error.

Section 2. Which methodologies can be used to research emotions' effects on memory?

There are several methodological approaches which can be taken to the study of emotion and memory, and each has their own influence on the experimental design and potential findings. These are discussed below.

Section 2.1. How can emotions be measured?

There are several components of emotion and a wide variety of ways in which these can be measured. Emotions can be measured by examining subjective feelings of emotion, as well as physiological, behavioural and neural responses to emotion (Coan & Allen, 2007). Examples of the different measurements which could be taken when studying emotion include:

i) <u>Behavioural responses to emotion</u>: Facial expressions are a critical way in which humans express their emotion and can be measured using human-observer-based coding systems, facial electromyography or using automated computer vision to analyse facial images (Cohn & Kanade, 2007). In extensive studies Ekman (e.g. 1992) has examined facial expressions in different cultures and concluded that they are universal, rather than culturally specific manifestations of emotion.

ii) <u>Physiological responses to emotion</u>: A set of photographs that was developed to study emotion (International Affective Picture System, Lang, Bradley, & Cuthbert, 2001) and rated along two dimensions of valence and arousal was validated by measuring physiological responses. These included skin conductance response to measure sweating, and reflexive eyeblinks which increase with unpleasant material (Lang, Greenwald, Bradley, & Hamm, 1993).

iii) Neural responses to emotion: Various neuroimaging techniques (including functional magnetic resonance imaging (fMRI) and electroencephalography (EEG)) have been used to measure blood flow and electrical activity of the brain, respectively, to examine how these change with the experience of emotion (Norris, Coan, & Johnstone, 2007).

iv) Subjective feelings of emotion: subjective reports of emotion have also been assessed by using diary-based studies and self-report time sampling of experiences in situ (Brandstatter, 2007). One advantage of this method is that naturally occurring emotions can be studied.

v) Questionnaire-based measures of emotion: There are standardised questionnaires which can be used to measure a variety of emotional states. These can measure levels of emotion to assess for a clinical disorder such as depression with the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). They can also be used to measure a range of positive and negative emotions and are particularly used in research examining mood; one example is the Multiple Affect Adjective Checklist which assesses several discrete emotions using ratings on 132 adjectives (see Gray & Watson, 2007 for a review).

One of the primary considerations when deciding which methodologies to use to research the effects of emotion is to decide whether to study the effect of naturally occurring emotions or whether to experimentally manipulate emotions in the controlled setting of a laboratory. The measures above could be used to measure both types of emotion but they may interfere to a greater or lesser extent with the feelings of the participant dependent on whether the emotion was naturally occurring or induced. For example; a questionnaire-based measure may provide an accurate measure of a person's general feeling of depression in their life, but in a laboratory experiment where the emotions induced may be short lived a questionnaire based measure may not be so appropriate.

Section 2.1.1. Study of naturally occurring emotions

The influence of naturally occurring emotions on cognition can be studied by investigation of a public event which was experienced as part of everyday life by a large number of people. One example of this type of research was conducted by Kensinger & Schacter (2006) who examined memory for the final game in the 2004 American League playoff series. By comparing the experiences of people who were fans of the winning team with fans of the losing team, Kensinger & Schacter (2006) were able to explore the influence of positive and negative emotions on memory for the same event. There are limitations in the use of this type of paradigm which include the inability to control the parts of the event to which people originally paid attention. This is one of the reasons why a great deal of research in this area is conducted within a laboratory setting.

Section 2.1.2. Experimentally manipulated emotions

There are a variety of ways in which the emotions of a participant can be manipulated in a laboratory setting. In psychological experiments the aim is normally to induce emotions of a similar intensity and valence with each participant. In order to do this emotions are often induced by presenting the participant with stimuli which have been designed to induce specific emotions. Although it is not possible, or assumed, that the emotions experienced by each participant will be the same, the aim is to produce similar emotional experiences for each participant. This may be done by presenting participants with an article to read which may induce a happy, neutral or sad mood (e.g. Handley & Lassiter, 2002), presenting participants with a film clip (e.g. Hemenover & Schimmack, 2007) or by playing clips of emotionally evocative music to participants (e.g. Witvliet & Vrana, 2007). After mood-inductions such as these the mood manipulation is generally checked using a standardised questionnaire.

In contrast to using standardised stimuli to induce mood, another method which can be used to induce emotions is to ask participants to recall events from their own life which make them feel a certain way (e.g. Berntsen, 2002). One of the difficulties of this method of inducing emotions is that the researcher has no control over the events which participants may recall and it is possible that some participants may have experienced more traumatic or euphoric events than other participants and therefore the emotions produced may differ both qualitatively and quantitatively between participants.

With the methods described above the aim is often to induce a relatively long lasting mood. This can influence the design of the experiment because mood inductions generally require experimental designs with between group comparisons of the influence of emotion. Emotions tend to be manipulated in a different way in experiments which are designed to examine the effect of different emotions on cognitive processes in the same participant. In this type of experiment participants may be presented with a series of pictures or words, each of which are designed to invoke an emotion of a certain valence or intensity. A database of photographs and words was developed by Lang and colleagues (Lang et al., 2001) to be used in the study of emotion. This database consists of hundreds of stimuli which have been rated in a series of studies by participants for levels of emotional valence and arousal. The stimuli from this International Affective Picture System have been used in a large number of studies to examine the influence of emotion on cognition (see Libkuman, Otami, Kern, Viger, & Novak, 2007).

The advantage of stimuli such as these are that complex experiments can be designed which need a large number of stimuli to be presented to participants. In experiments with a large number of stimuli the emotional experience of each individual participant may not be measured, instead ratings are provided by a different group of participants, ideally sampled from the same population as the participants conducting the experiment. This is to avoid the contamination of experimental manipulations which may occur if participants are required to complete the experimental task in addition to rating the stimuli for emotion.

Section 2.2. How can memory be researched?

The study of memory can also be divided into that of naturally occurring memories, and experimentally produced memories, in the same way as for the study of emotion, as described above. The way in which the study of memory and emotion can differ between autobiographical and laboratory controlled memories will be discussed below.

Section 2.2.1. Study of autobiographical memories

Three ways in which emotional autobiographical memories have been studied are in the examination of eyewitness memory, flashbulb memory and memory for traumatic experiences. The research has often focused on whether emotion enhances or diminishes the strength of memory for an event and whether special mechanisms are required to account for the effects of emotion on memory (Schooler & Eich, 2000). The accuracy of eyewitness testimony is very often impaired and different aspects of the event may be remembered better than others. Memory for central details may be improved but at the cost of an impairment in memory the peripheral details, as has been demonstrated in studies which have found a weapon focusing effect, whereby memory is impaired in the presence of a gun or knife (Loftus, Loftus, & Messo, 1987). Flashbulb memories were first described by Brown & Kulik (1977) and refer to vivid memories for hearing about salient news stories, such as the assassination of President John F. Kennedy, or more recently the terrorist attacks on the World Trade Center in New York. These flashbulb memories were characterized as being incredibly accurate and involving unique memory processes, although later research has refuted both the level of accuracy of such memories (e.g. McCloskey, Wible, & Cohen, 1988) and its unique mechanism (e.g. Conway et al., 1994). Memory for traumatic events has been shown to be accurate, although not flawless, for a variety of experiences, including kidnapping and concentration camp experiences and the study of these memories has at times been wrought with heated debate (Schooler & Eich, 2000). One of these debates has been whether traumatic memories can be completely forgotten and then accurately recovered.

The study of emotional disorders has often included an examination of autographical memories and how their characteristics may differ between people with and without a certain disorder. For example Williams et al. (2007) found that the specificity of autobiographical memories can have an important impact on clinical depression, and that when this specificity of memories is modified it can reduce depression.

Section 2.2.2. Experimentally produced memories

Memories of events that happen in a controlled laboratory setting or memories of various stimuli that are presented to participants within an experiment can be measured in different ways. There are normally three distinct phases in experimental memory research: an encoding or study phase in which materials are presented to the participant, a retention interval and a retrieval or test phase in which the participant attempts to respond to a question, for which the answer involves the use of the initially studied information (Lockhart, 2000). Experimental manipulations at each of these stages of memory research can be used to provide insight into the cognitive processes involved in memory. In this thesis the influence of emotion on memory will be considered by experimental manipulations at the times of encoding and retrieving a memory. The impact of manipulations at these stages of the memory process are briefly described below. There can also be manipulations during the retention interval but these are not discussed here.

The encoding stage in memory research can be manipulated by altering the mental state of the participant at the time they are encoding material, e.g. by inducing a particular mood state as described above. Altering the demands of the task performed whilst encoding the material can also affect the level of memory performance, e.g. asking participants to judge the honesty of a person can lead to subsequent higher recognition than asking them to judge the sex of the person (see Lockhart, 2000).

With regard to the retrieval phase, in memory research up until the 1970s most researchers considered that different methods of evaluating memory were just alternative methods for measuring a common underlying construct, but since then memory tasks have been seen as possibly involving different processes that potentially tap different memory subsystems (Lockhart, 2000). One often used measurement of memory is the recognition test. In this participants are presented with exactly the same material in the test phase as in the study phase. Items may be presented singly in a free-choice recognition test (yes, no response required) or in a forced-choice recognition test one previously studied item is presented along with other new (distractor) items. The choice of distractors is important in recognition tests as the degree of similarity between old and new items is one factor which will affect the difficulty of the test.

In recognition tests it is important to take account of the possibility of guessing and achieving chance success, although in forced recognition tests participants are more likely to make an unbiased judgement between alternatives (Lockhart, 2000). The consideration of bias is particularly important when investigating the influence of emotion on memory as emotions of different types have been found to have different effects on recognition bias. Phaf & Rotteveel (2005) found that induced positive affect led to a more liberal recognition criterion for test words, and that negative affect led to more cautious tendencies without any effect on accuracy of recognition memory. Levine & Bluck (2004) found similar results with memory for a real world event in that participants who were happy about the event having occurred had a lower threshold for judging events as having occurred than participants who had a negative reaction to the original event. Bless et al. (1996) found that participants who had a happy mood induced were more likely to 'recognise' information that was consistent with their general knowledge about eating in a restaurant, whereas people with a sad mood induced tended to be more conservative and accurate in their judgements. Bless et al. (1996) also found that happy participants outperformed sad ones when performing a secondary task whilst listening to a story on which their memory was later tested, and took this to suggest that happy moods do not decrease cognitive capacity or processing motivation in general, because if this were the case an impaired secondary-task performance would be expected. In contrast, Forgas (1998) found that positive mood reduced and negative mood improved memory performance. Although different information processing strategies have been shown with positive and negative moods these are not always related to the objective accuracy of accounts and it appears that people may believe they remember happy events more clearly than they do (Levine & Bluck, 2004).

These findings may differ in the degree to which they are due to an influence of emotion at the time of encoding or retrieval.

Other types of memory test include cued recall where participants are presented with a cue and required to recall an item associated with that cue; serial recall in which participants are instructed to recall items in the order in which they were presented and free recall in which participants are asked to recall items in any order.

All the tests above have been described as measuring explicit memory where there is a conscious effort to fulfill the instructions to remember. This is in contrast to implicit memory tasks where memory is revealed in responses to the task even though the participant may not be aware that a form of remembering has occurred. Tasks of implicit remembering can include word-fragment completion and the level of preference for an item, preference has been taken as a measure of memory in techniques such as the mere exposure paradigm. This paradigm will be used in Chapter 2 of this thesis to examine the influence of factors at the time of retrieving a memory. We will also be examining how the Remember/Know paradigm impacts on findings of an emotional influence on memory.

Section 2.2.3 Interactions between experimental design and findings

There can be an interaction between the factors of experimental design, which have been described above, and the experimental findings, particularly in the influence of emotion on memory. The type of measurement of memory which is used can affect the findings uncovered. One example of this relates to investigations of recollection. Recollection was found to be enhanced by negative emotion when measurements were based on a paradigm which required participants to distinguish between which items they 'Remember' and which items were 'Known' (Ochsner, 2000). In contrast, recollection has been found to be impaired by negative emotion when measurements were based on a paradigm which required participants to identify in which half of the study phase an item had initially appeared (Aupee, 2007).

Section 3. Emotion and memory

Section 3.1 What influence can emotion have on memory?

Feelings of emotion accompany many events experienced in life and can influence the memories of these events. Memories of traumatic and upsetting events may appear to be vivid and clear but on closer inspection there may only be some aspects of the event for which the accuracy of memory is enhanced, whilst other aspects of the event may be completely forgotten (Wagenaar & Groeneweg, 1990). Emotion clearly has an effect on memory, but there is no agreement in the literature on whether its effects are enhancing (e.g. Ochsner, 2000) or detrimental (e.g. Aupee, 2007). We need to be able to define and predict in which conditions memory is enhanced and in which conditions it is impaired by emotion, in order to understand the mechanisms by which memory is influenced. Memory is not a single unified process and the effects of emotion on memory have been examined for different processes (encoding, consolidation or retrieval) and using different assessments (e.g. recognition, free recall) (see Fox, 2008 for a recent review). Before we can hope to understand the overall effect of emotion on memory we first need to understand the effects it has on any one of the processes.

Section 3.2. Which processes underlying memory may be affected by emotion?

The processes by which emotions may have their enhancing effect on memory are not clear. Early research demonstrated the effect that mood has on encoding and retrieval of memory (e.g. Bower, 1981) and a recent review confirmed that people process, encode and retrieve information differently depending on their mood (Levine & Bluck, 2004). The main focus in this thesis will be on the encoding and retrieval stages and these will be reviewed below, although there will be brief consideration of emotion's influence on consolidation.

Section 3.2.1. Encoding

Two theories of how emotion may influence the encoding process of memory are going to be discussed here. One theory is that emotion alters the allocation and distribution of attention to an event or stimulus (e.g. Christianson, 1992) and another theory is that emotional materials are relatively rare or unusual and that this enhanced distinctiveness of emotional stimuli may lead to the enhancement of memory (e.g. Schmidt, 2002).

Section 3.2.1.1 Attention

Emotion may influence attentional processes at the time of encoding information into memory by emotional stimuli garnering more attentional processing capacity or by a spatial narrowing of the distribution of visual attention onto emotional stimuli.

i) Additional attentional processing capacity

The need for additional attentional resources to enable the more successful encoding of emotional items and lead to their enhancement in memory has been found when memory is assessed by recognition (e.g. Clark-Foos & Marsh, 2008; Talmi, Schimmack, Paterson, & Moscovitch, 2007) and by free recall (Kern et al., 2005). Talmi et al (2007) compared memory for emotional and neutral pictures that were encoded whilst participants concurrently completed a divided attention task of auditory discrimination or whilst participants could give their full attention to encoding the pictures. They found the use of additional attention at encoding could completely account for an emotional enhancement in memory of positive pictures. In contrast, the enhancing effects of negative emotion on memory were found to be independent of attention. Similarly, Clark-Foos & Marsh (2008) found that dividing attention at encoding and during the memory test, by participants performing a random number generation task, did not effect the negative emotional enhancement of word recognition relative to neutral words. Again similar results were found by Kern et al (2005) that dividing attention at the time of encoding worsened neutral, but not negative, memories.

The patterns of findings across these studies are very similar but differing interpretations of what they reveal about the role of attention in emotion's effects on memory have been given by the authors. Kern et al (2005) interpreted their results within the two-path theory proposed by Christianson, Loftus, Hoffman, & Loftus (1991) and argued that pre-attentive processing can account for the emotional advantage of negative stimuli. They rejected the second path of Christianson et al's (1991) theory of post-stimulus elaboration as an account of their findings, as there was no opportunity for this elaboration to occur due to the blocking of rehearsal between the encoding of stimuli and testing of memory. Talmi et al (2007) suggested that negative emotion has an effect on memory that is separate from attentional processes, with the effects of emotion on memory direct and independent from the effects on attention. In contrast, Clark-Foos & Marsh (2008) argued that the involvement of attention in the emotional enhancement of memory is dependent upon circumstances. They suggested that there may be a conscious route by which emotion enhances memory through the allocation of additional attention at encoding to negative emotional stimuli, but when this route is constrained there may be a more automatic route through which the emotional enhancement occurs. Clark-Foos & Marsh (2008) emphasised that the laws which will be found to govern the relationship between emotion and memory will greatly depend on the context of the findings and therefore may differ with different stimuli and tasks.

Studies such as those described above have demonstrated that emotional stimuli can be processed with a reduced amount of attention at the time of encoding and therefore in circumstances where attentional capacity is reduced, e.g. during the completion of a concurrent task, emotional stimuli receive more complete processing than neutral stimuli and this may lead to more accurate memory for the emotional than neutral stimuli. This suggests that attention may be deployed in a different way for emotional and neutral stimuli, and this deployment may result in better memory for emotional than neutral stimuli.

ii) Attention narrowing

Another way in which the deployment of attention may differ between emotional and neutral stimuli could be in the spatial distribution of attention across a visual stimulus. Research investigating memory for central and peripheral elements of emotional and non-emotional scenes has suggested that attention narrowing may occur with negative stimuli (Kensinger et al, 2007b). There are suggestions that whilst negative emotion leads to a narrowing of attention, positive emotion leads to a broadening of attention (Fredrickson, 2001). It has been argued that a positive mood may lead to a shift in information processing style by relaxing inhibitory control, leading to a reduced tendency to narrowly focus attention (Freitas, Katz, Azizian, & Squires, 2008; Rowe, Hirsh, & Anderson, 2007). The degree to which attention is broadened with positive emotion has been found to depend on the level of approach motivation. Low approach motivated positive affect has been associated with a greater breadth of attention than high approach motivated positive affect (Gable & Harmon-Jones, 2008).

Attention narrowing at the time of first witnessing an event has been invoked to account for the phenomenon of weapon focus in memory, where there is an impairment of memory for an event in which there was a weapon present (Loftus et al., 1987). Groeger (1997) argued that attention narrowing may not be due to narrowing in the distribution of attention across an event, but a narrowing in the span of attention on different parts of an event. It may be that with attention narrowing less information can be attended to but that what is attended to is well remembered (Groeger, 1997).

Other researchers have investigated memory with alternative definitions of central and peripheral elements of a scene and have found indications of the involvement of attention. Cook, Hicks, & Marsh (2007) found that increased attention toward valenced material led to a reduction in the binding of its contextual details into memory (another possible aspect of peripheral information). Touryan, Marian, & Shimamura (2007) found that the memory for objects embedded in the periphery of a scene was better for negative than neutral objects, but that associative memory for these items and their peripheral information was worse for scenes with a negative than neutral object. Research by Easterbrook (1959) is often cited as providing support for the proposal that this attentional narrowing is a defensive motivational reaction to emotional arousal (e.g. Christianson et al., 1991; Kensinger, Garoff-Eaton, & Schacter, 2006). It is this motivational reaction which is thought to lead to a focus on central rather than peripheral elements of a scene. Easterbrook (1959) investigated animal learning and found that an animal which was aroused by means of food deprivation became less sensitive to information at the periphery of an event.

iii) Pre-attentive processes

Studies measuring eye movements have shown that visual attention is drawn preattentively to emotional, over neutral, pictorial stimuli, suggesting that emotional content is likely to engage attention in early processing stages (Nummenmaa, Hyona, & Calvo, 2006). This may lead to a difference in the amount of information encoded from emotional and neutral stimuli. The possibility of pre-attentive processing of emotional stimuli (as argued by Kern et al, 2005) has been directly investigated and it was found that although affective processing of emotional and non-emotional pictures can occur without overt attention, some resources for covert attention are required (Calvo & Nummenmaa, 2007). The ability to process the gist of scenes in peripheral vision is thought to lead to the selective attentional orienting seen with emotional stimuli but direct fixations on the stimuli are required to enable processing of the specific content of both emotional and neutral scenes (Calvo, Nummenmaa, & Hyona, 2008). This suggests that processing of emotional stimuli does not occur pre-attentively and that covert attention is required to encode emotional stimuli in a way that leads to their enhancement in memory over neutral stimuli. Both positive and negative pictures have been shown to capture attention more quickly than neutral stimuli (Calvo & Lang, 2004; Lobue & DeLoache, 2008; Nummenmaa et al., 2006). This capturing of attention has been found to be due to the emotion conveyed rather than schematic properties of the images as evidenced by preferential detection of fear-conditioned neutral faces compared with neutral and happy faces (Milders, Sahraie, Logan, & Donnellon, 2006).

Section 3.2.1.2. Distinctiveness of emotional events

Emotional stimuli may be remembered better because they are more rare or unusual and are therefore distinctive and stand out relative to background neutral events. Distinctiveness has been shown to enhance memory regardless of emotionality (Hunt & McDaniel, 1993) and therefore this characteristic of emotional stimuli may contribute to its enhancement in memory (for a review see Talmi, Luk, McGarry, & Moscovitch, 2007). Emotional items can be more distinct in both an *absolute* and *relative* sense because they possess unique features which are not shared with other typical items that are stored in long-term memory and because they are distinctive relative to other neutral items presented within an experimental context (cf. Schmidt, 1991).

In studies using the Remember-Know paradigm the advantage for Remember responses both with emotional words and pictures has been taken as evidence that emotional stimuli are encoded more distinctively than neutral stimuli leading to subsequently different experiences during recollection (Dewhurst & Parry, 2000; Ochsner, 2000). Dewhurst & Parry (2000) found an enhancing effect of emotion on recollection only when a mixed list of emotional and random-neutral words was presented, but not when pure lists of emotional words and random-neutral words were presented. This suggested that the relative distinctiveness of emotional stimuli may be responsible for the enhancing effect of emotion.

Section 3.2.2. Consolidation

There is evidence from pharmacological studies that emotion can influence the processes of consolidating memories. The administration of a powerful stimulant with arousing properties (e.g. amphetamine) before and after learning a list of words was found to lead to improvement in memory for those words (Soetens, Casaer, D'Hooge, & Hueting, 1995). Emotionally-arousing events and stimuli are more likely to be consolidated into long-term memory and the mechanisms underlying this process are probably linked to actions which are modulated by the amygdala with involvement of the hippocampus (Fox, 2008).

Section 3.2.3. Retrieval

There are a number of studies which have found that emotion can influence the retrieval process of memory.

In a review of research into autobiographical memory it was concluded that the overgenerality in memory, often seen in depression, results from a failure to retrieve episodic memories, rather than a failure in the initial encoding of these memories (Williams et al., 2007). Mathews, Richards & Eysenck (1989) found that when clinically anxious people, in comparison to controls, listened to and wrote down homophones the former were more likely to write down the threatening meaning, rather than neutral meaning, of the homophone. The interpretive bias that operates with these anxiety-prone individuals in making them preferentially aware of the more threatening meaning of such events (Mathews et al., 1989) may be a function of a different retrieval strategy to that used by non-anxious individuals.

Different patterns of emotional enhancement have been found when different tasks are used to measure memory and this may indicate that different tasks encourage participants to retrieve memories in different ways. Better memory for positive than negative trait information was found when information was encoded with reference to the self, but not with reference to another person, when memory was measured by free-recall but not when it was measured by recognition (D'Argembeau, Comblain, & Van der Linden 2005). D’Argembeau et al. (2005) suggested retrieval processes may explain some part of their findings as the provision of cues at the time of retrieval in the recognition task seemed to eradicate the emotional differences found with free recall.

Neuropsychological studies using fMRI have shown greater and differential activity with successful recognition of emotional, compared to neutral items, both at the time of encoding, and at the time of retrieval (Dolcos, LaBar, & Cabeza, 2004, 2005). These findings have also been shown to hold when examining the retrieval of neutral stimuli encoded in an emotional context, in contrast to emotional stimuli themselves. Smith, Henson, Rugg, & Dolan (2005) conducted an fMRI study and found that distinct neural circuits are engaged during the retrieval of memories which were formed in association with emotional contexts, in comparison to those formed in association with neutral contexts. Smith, Dolan & Rugg (2004) examined recognition memory for neutral objects that were associated with positive, negative or neutral contexts at encoding. They found additional ERP effects at early and late stages of retrieval for objects that were studied in emotional contexts. Larger and more sustained ERP effects have also been shown in the recognition of words that were studied in the context of negative sentences, rather than neutral sentences (Maratos & Rugg, 2001).

It appears that there does seem to be an effect of emotion on the way memories are retrieved. Further investigation is needed to find out how these processes of retrieval may differ. Retrieval effects in memory have been suggested by research into mere exposure (Whittlesea & Price, 2001) and this will be explored in chapter 2.

Section 3.2.7. Do different types of emotion exert influence through different mechanisms onto different memory processes?

In studies of emotion and memory, emotion has been most commonly defined along the two dimensions of arousal and valence. Some studies have found that the better memory for emotionally arousing stimuli is independent of emotional valence (Bradley et al., 1992). Nevertheless, the importance of focusing on discrete emotions has been recognised (Levine & Pizarro, 2004) and several studies have found that particular emotions can have different effects on cognitive processes, even when they evoke similar levels of arousal (Levine & Pizarro, 2006). Positive and negative emotions that are similar in intensity of arousal have been shown to have very different effects on how information is processed and remembered (Bless et al., 1996; Bodenhausen et al., 1994; Forgas, 1998; Levine & Bluck, 2004). In studies of autobiographical memory there is also no clear picture of the relationship between emotional intensity and valence (Talarico, LaBar, & Rubin, 2004).

Buodo, Sarlo, & Palomba (2002) examined attentional resources available whilst participants viewed pleasant and unpleasant highly arousing images. They found that participants took longer to respond to a tone whilst viewing sexual images (positive valence) and images of blood/injury (negative valence) than other images, but there was no difference in reaction time when viewing images of sport/adventure (positive valence) and threat (negative valence) (Buodo et al., 2002).

Section 3.3. Types of memory affected by emotion

Section 3.3.1. Recollection and familiarity

In addition to examining overall levels of memory accuracy it is also possible to consider the way in which emotional material is better remembered, and the form of the memory which contains the remembered material. Studies using the Remember-Know paradigm have found that emotional enhancement of memory can be found in recollection, but not in familiarity (Dolcos et al., 2005; Ochsner, 2000).

Ochsner (2000) used a remember / know paradigm to investigate the processes of recollection and familiarity that may underlie recognition and found that recollection was significantly boosted for negative or highly arousing photographs, and boosted to a lesser degree for positive stimuli. There was no effect of emotion on familiarity. Ochsner (2000) suggested that this increased recollection of negative over positive photos may be due to the increased relevance of negative photos to chronically important goals (i.e. staying away from danger) in contrast to the positive stimuli which may have been less relevant to personal goals. Alternatively, it may have been that the emotion from positive stimuli enhanced the processing of all (studied and nonstudied) items and therefore any increased processing fluency as a result of previous exposure to an item was negligible by comparison (Ochsner, 2000).

The effects of emotion on recollection have been confirmed in several studies using a Remember-Know paradigm. Enhanced recollection has been found for pleasant and unpleasant pictures compared to neutral pictures when tested after one year, with no effect on familiarity (Dolcos et al., 2005). A similar pattern of results has been found with words, with positive or negative words subsequently better recognised than emotionally neutral words, and differences in recollection of the stimuli, as opposed to familiarity, as measured by number of Remember or Know responses (Dewhurst & Parry, 2000). An examination of negative emotional valence and arousal found that both factors led to increased numbers of remember responses for negative compared to neutral words (Kensinger & Corkin, 2003).

However, inconsistent results have been found when using a different methodology to study recollection. Aupee (2007) examined recollection using the Process Dissociation Procedure (PDP) (Jacoby, 1991). The Process Dissociation Procedure was developed by Jacoby (1991) to measure recollection and familiarity within a task. Recollection is measured as the difference in responding when people are specifically directed to *not* use responses from a particular study episode (an exclusion condition) compared to when they are directed *to* use responses from that study episode (an inclusion condition). For example people may be instructed to respond ‘yes’ to some items which they have seen and heard in an earlier encoding task, and to some other items only if they were heard in the earlier encoding task but not if they were also seen. Aupee (2007) used a variant of PDP which required participants to complete two recognition tests where in one test they must identify pictures presented in the first half of the training phase, and not those presented later, or ‘new’ pictures. In the second test they must discriminate between pictures presented in the second half of the training phase and other pictures. Aupee (2007) found evidence that in this case, recollection of negative and positive pictures was lower than for neutral pictures. Aupee (2007) suggested that this lack of emotional enhancement, in contrast to that found in many earlier studies, may be due to the information upon which recollection must be based when using the PDP method. Estimates of recollection derived from PDP are greatly determined by the ability to recollect a very targeted piece of information, such as when the stimulus was presented (Aupee, 2007). This is in contrast to studies using estimates of recollection based on a Remember-Know judgement where it may be that ‘remember’ judgements were based on a memory of the emotional reactions and associated thought at the time of encoding, rather than recollection of specific perceptual details of the stimulus (Aupee, 2007).

Section 4. Summary

In this chapter I have examined a range of issues including the psychology of emotion, suitable methodologies for examining the influence of emotion on memory and the different cognitive processes through which emotion might exert its effects on memory. The aim of this literature review was to place the research of this thesis within the context of the wider relevant literature which is not considered within the experimental chapters. In this thesis the later chapters will focus on aspects of encoding a memory, however, this thesis begins by examining retrieval effects in memory using a mere exposure paradigm. The mere exposure phenomenon was first investigated by Zajonc (1968) who found that when stimuli are presented very briefly, repeated exposure may lead to an increased preference for the stimuli with an accompanying absence of any explicit recognition. In chapter 2 this paradigm is used as a way of briefly presenting participants with stimuli to assess different strategies of retrieving a memory (as investigated by Whittlesea & Price, 2001) and of examining the influence this may have on the emotional enhancement of memory. In chapter 3, the implications of using different methodologies to examine the relationship between memory and emotion are examined by comparing memory assessed with a Remember/Know/Guess paradigm and other measures of recognition. We also examine how findings from the Remember/Know/New paradigm compare to a newer paradigm for investigating recognition memory in which memory for the specific visual details of stimuli is assessed (Kensinger et al., 2006). In chapter 4, we begin to consider effects at the time of encoding a memory and use the visual specificity paradigm to examine the relationship between attentional factors and the emotional influence on memory. In the last experimental chapter (chapter 5), we consider how encoding factors other than attention may be involved in the emotional enhancement of memory for specific visual details.

Chapter 2. Influence of emotion on processes at the time of retrieving a memory

A limited amount of published research has directly investigated the influence of factors at the time of retrieval on the emotional enhancement of memory (Fox, 2008). The research that there is has mainly been conducted using neuroimaging rather than behavioural methods, with the aim of examining neural activity at the times of encoding and later retrieving memories. Greater and differential neural activity has been found for successfully recognised emotional items, compared to neutral items, both at the time of encoding and at the time of retrieval with studies using fMRI (Dolcos et al., 2004, 2005). Differential activity at retrieval has also been found using the more time sensitive method of measuring event-related potentials (ERPs) (Maratos & Rugg, 2001; Smith et al., 2004).

Findings from neuroimaging research indicate that there may be processes at the time of retrieving memories which are different for emotional than non-emotional memories. There are some findings from behavioural studies which also indicate this possibility. The study of recognition memory and emotion has often been broken down into an examination of different subjective experiences of memory through the use of the Remember-Know procedure, where participants differentiate between recognition based on specific memories for the episodic context (Remember responses) and recognition accompanied only by a sense of familiarity (Know responses) (e.g. Dolcos et al., 2005; Ochsner, 2000). An emotional enhancement of recollection appears to be a robust findings with effects demonstrable immediately after study (Dewhurst & Parry, 2000), after 2 weeks (Ochsner, 2000) and after one year (Dolcos et al., 2005). There are different interpretations of the results obtained from this Remember-Know procedure, in one of these it is argued that recollection and familiarity are two separate and distinct memory retrieval processes (Yonelinas, 2001). If this specific interpretation is used this may indicate that the finding of emotional enhancement in recollection, but not familiarity (e.g. Dolcos et al., 2005; Ochsner, 2000) could result from different retrieval processes being used to search for memories of emotional and non-emotional content. Effects at the time of retrieval may be in addition to explanations based on the more distinctive encoding of emotional stimuli which it has been argued leads to different subjective experiences of memory for emotional and neutral stimuli (Dewhurst & Parry, 2000).

Research into memory for briefly presented non-emotional stimuli has found evidence for retrieval effects. The mere exposure paradigm is one methodology which has been used to highlight retrieval effects in memory (Whittlesea & Price, 2001). In the first two experiments of this thesis we will use a paradigm from Whittlesea & Price (2001) to examine how retrieval strategies may differ between emotional and neutral stimuli. The mere exposure effect is the preference for previously exposed stimuli in the absence of recognition for those same stimuli. The mere exposure effect has been explained with reference to an implicit or explicit awareness of a memory (e.g. Seamon et al., 1995). However, Whittlesea & Price (2001) proposed an alternative explanation, namely that tasks of preference and recognition in traditional mere exposure experiments encourage the use of different processing styles at the time of retrieval. They argue that these different processing styles can account for the instances where recognition succeeds and where it fails in these tasks. Whittlesea & Price (2001) argued that recognition of a stimulus results from the experience of increased fluency of processing which occurs when a stimulus is encountered again after initial exposure. They argued that for successful recognition to occur the strategy at retrieval must enable the experience of this enhanced fluency of processing. In a series of experiments Whittlesea & Price (2001) demonstrated that different levels of recognition performance depended on retrieval processing style, which was manipulated by task instructions. Successful recognition was shown with nonanalytic strategies at retrieval and failed recognition with analytic strategies at retrieval. By varying the number of times stimuli were presented they also demonstrated that level of recognition was sensitive to the amount of pre-exposure. Nonanalytic strategies of processing at retrieval were induced by giving participants instructions which gave them no motive to analyse stimuli for distinctive features, instead they would be motivated to process items nonanalytically by considering their overall image. Analytic strategies of processing were induced by giving participants instructions which gave them a motive to analyse the stimuli for the details of distinctive features. Although the Whittlesea & Price experiments were primarily designed to understand the mere exposure effect, they also provide a powerful theoretically motivated paradigm for exploring retrieval strategy effects in recognition memory. It is on this basis that the experiments in Chapter 2 and 3 use this paradigm to explore the retrieval of emotional stimuli.

The exposure durations in the mere exposure paradigm described in Whittlesea & Price (2001) are much shorter than has been used in previous research investigating memory and emotion. However, these durations should be suitable for investigating memory for emotional and neutral stimuli because even at rapid presentation rates of stimuli the ability to discriminate emotional from neutral pictures has been demonstrated by measuring physiological responses such as skin conductance (Smith, Low, Bradley, & Lang, 2006). There has been previous research with emotional stimuli and the mere exposure paradigm but the focus of this was limited to preference of stimuli rather than subsequent recognition (e.g. Harmon-Jones & Allen, 2001; Robinson & Elias, 2005; Witvliet & Vrana, 2007) and did not seek to systematically manipulate retrieval style.

There may be several routes by which the emotion of a stimulus influences its subsequent retrieval. Emotion has been shown to affect the fluency of processing experienced when encountering both visual and auditory stimuli (see Ferre, 2003). A specific example is the more accurate recognition of affective than neutral words which has been demonstrated even with words that are only presented extremely briefly to participants (Kitayama, 1990). This may be due to increased fluency of processing experienced when viewing the emotional words. For an emotional enhancement of memory to occur it may be necessary to experience this enhanced fluency of processing which is associated with affective stimuli. Whittlesea & Price (2001) argued that fluency of processing is enhanced with nonanalytic processing at retrieval. We might thus predict that analytic processing at retrieval would prevent the experience of enhanced processing fluency and therefore block or reduce any emotional enhancement of memory.

Nonanalytic processing may be more efficient than analytic processing with emotional stimuli by harnessing the enhanced memory for gist that has been found with emotional events. Emotion has been shown to enhance memory for the gist of an event at the expense of memory for details of the event (Adolphs, Tranel, & Buchanan, 2005; though cf. Kensinger et al., 2006). The experimental findings of studies which failed to find an emotional enhancement of memory may be explained by considering how the task affected processing style at retrieval. In a task where participants were asked to recall targeted perceptual aspects of experimental stimuli (i.e. in which half of an experimental list stimulus pictures were presented) the recall of emotional stimuli was worse than of neutral stimuli (Aupee, 2007). This may be because the task induced participants to use an analytic processing style at retrieval and may suggest that in some cases analytic processing may not just block any emotional enhancements of memory but actually reverse them.

This study tests the hypothesis that different strategies in the retrieval of emotional stimuli contribute to the emotional enhancement of memory. If people spontaneously use a nonanalytic processing strategy when attempting to recognise emotional material then we would expect to see an advantage for emotional material, over neutral, in traditional recognition tasks. However, we would expect any emotional enhancement effects to disappear in an analytic processing strategy task as this would prevent participants from using the successful strategy that we propose normally gives an advantage with emotional material. There is one additional issue of retrieval style in recognition tests that we wish to explore. In some recent research participants were asked to perform a recognition task and then subsequently make a Remember / Know / Guess (RKG) judgement (e.g. Dahl, Johansson, & Allwood, 2006; Dewhurst & Parry, 2000; Dougal & Rotello, 2007). It is possible that having to distinguish between Remembered and Known items in this way may encourage participants to use a different strategy than in a traditional recognition task and that this change may be to a more analytic strategy. Thus, an additional hypothesis we will test is that making subsequent RKG judgements after first identifying which picture was recognised may encourage an analytic strategy of retrieval and reduce emotional enhancement in recognition.

Section 1. Experiments 1A and 1B: Preference and Recognition

Section 1.1. Introduction

We have adapted the procedure used by Whittlesea & Price (2001) to allow comparison of performance across positive, negative and neutral blocks of stimuli. All other aspects of the design are a replication of Whittlesea & Price (2001). We first assessed whether it was possible to obtain the mere exposure effect with a stimuli set drawn from the International Affective Picture System (IAPS) (Lang et al., 2001). We also wanted to see if there was an emotional enhancement effect in these tasks with stimuli presented for the very short durations used by Whittlesea & Price (2001). We predicted there would be an emotional enhancement with greater recognition memory for negative and positive than neutral photographs.

Section 1.2. Method

Design

In these experiments the influence of emotion (positive, negative and neutral) on judgements of preference and recognition was examined. Participants were shown negative, neutral and positive stimuli in a within-participant blocked stimuli design and completed in either the preference or recognition judgement task. Memory performance was tested using a two-alternative forced choice design.

Participants

12 University of Nottingham students participated in Experiment 1A (Mean age 20.58 years (SD 2.97yrs); 7 female), and 12 in Experiment 1B (Mean age 20.00 years (SD 1.41yrs); 5 female). All participants received an inconvenience allowance of £2 and were native English speakers. Exclusion criteria were that participants who had a phobia of animals should not take part, as several of the photographs were of animals. None of the participants in experiments 1A – 2E participated in more than one of the experiments.

Materials

One hundred and eighty photos from the International Affective Picture System (Lang et al., 2001) were selected as stimuli. Erotic photos or those of extreme mutilation were excluded for ethical reasons. Normative ratings of arousal and valence (from Lang et al., 2001) were used to create three groups of 60 photos of negative, neutral or positive valence and to match positive and negative photos on arousal (See Appendix 2.1 for IAPS photo numbers). Within each group of stimuli (positive, negative or neutral) there were pairs which were matched for arousal (within one point on the Likert type 1-9 scale of arousal ratings from Lang et al., 2001). These arousal-matched pairs were used for the two –alternative-forced-choice recognition test. Half of the pairs comprised stimulus set A and the remainder comprised stimulus set B. Photos were selected to maximise heterogeneity of content within each valence group and across the pairs that were matched for valence and arousal. The proportion of photographs of people, animals and inanimate objects / scenes were similar across valence groups and stimulus sets A and B. Mean ratings for valence and arousal were: positive valence 7.16 (SD 0.54), arousal 5.12 (SD 0.81); neutral valence 5.01 (SD 0.56), arousal 4.66 (SD 0.87); negative valence 3.02 (SD 0.53), arousal 5.15 (SD 0.75). Within each valence group stimulus sets A and B had similar means and standard deviations for valence and arousal. Within each valence group of stimuli one third were presented once, one third three times, and one third five times. This was part of the original experimental design of Whittlesea & Price (2001) and allowed for a demonstration of increasing levels of recognition across repetitions. Presentations of photographs were approximately 7.6 cm square (246 by 246 pixels maximum), with some variability to allow for presentation of photos without distortion of their original proportions. Photos were presented on a Compusys PC with a 17" monitor with a 75 Hz refresh rate and screen resolution of 1024 by 768 pixels. The experiment was conducted using E-Prime (version 1.1). Ethical approval for this study was obtained from the Ethics Committee of the School of Psychology, University of Nottingham.

Procedure

To allow informed consent participants were told they would be shown some photographs which would vary in pleasantness. Participants were told they would be shown three series of rapidly presented photographs and after each series they would complete a task relating to those pictures. All subsequent instructions appeared on computer.

Study Phase:

Participants were initially shown a practice study phase Rapid Serial Visual Presentation (RSVP) of 10 photographs to familiarise them with the presentation rate. All example photos were of neutral valence and were single objects against a plain background, in contrast to the complex scenes used for experimental stimuli. Of the 10 practice photographs, 9 appeared for 40 msec and the last photo appeared for 160 msec. This was to aid participants' memory of this image which was used in the later practice task. Participants were then shown the study phase for the first valence block (i.e. positive, negative or neutral photos). Photographs were presented in an RSVP with 40msec exposure per picture and no interstimulus interval.

In each study block participants were shown 30 different photographs. Participants were shown photographs from one set of A or B, with the unexposed set used to create matched pairs during the test phase. The use of sets A and B for targets or distractors was counterbalanced across participants. From each set of 30 photographs; 10 were shown once, 10 three times and 10 five times. This resulted in an RSVP stream of 90 photographs in three study blocks with 270 photographs being shown in total across the 3 study blocks. Each RSVP stream lasted 3.6 seconds. The order of photographs in the study phase was randomised for each participant, with the exception that repeated presentations of the same item were separated by at least 2 other photographs. The selection of photos to be shown 1, 3, or 5 times in the study phase block was randomised for each participant. A fixation cross appeared centrally for one second before the RSVP began. Participants were not given task instructions until after the first study phase and so were unaware of the exact nature of the task until this time.

Retrieval phase:

Participants then completed two examples of the retrieval task with target stimuli from the practice study phase. In each test trial participants were shown a pair of photographs. One member of the pair ('the target') was from the earlier RSVP, the other member of the pair ('the distractor') was from the corresponding unexposed set. The target and distractor were matched for valence and arousal. In Experiment 1A participants were asked which picture they preferred. Participants had to choose the left or the right photograph by pressing '1' or '9' respectively on the keyboard. The test question and response keys were shown under each pair of photographs. After the practice examples, participants completed the test phase for the first valence block. There were 30 test trials for each valence block. Each photo was shown only once in the test phase. The pair of photos was shown side by side, with the location of the old item chosen at random. There was a new random order of test trials for each participant.

After completing the test phase for the first valence block, participants were shown the study phase for the second valence block. This was in the same format as the first valence block. Participants then completed the test phase for the second valence block (but without any example tasks). Participants were then shown the study phase for the third valence block and then completed the test phase for the third valence block. The order of the valence blocks of positive, negative or neutral stimuli was counterbalanced across participants. Participants were debriefed and thanked for their participation.

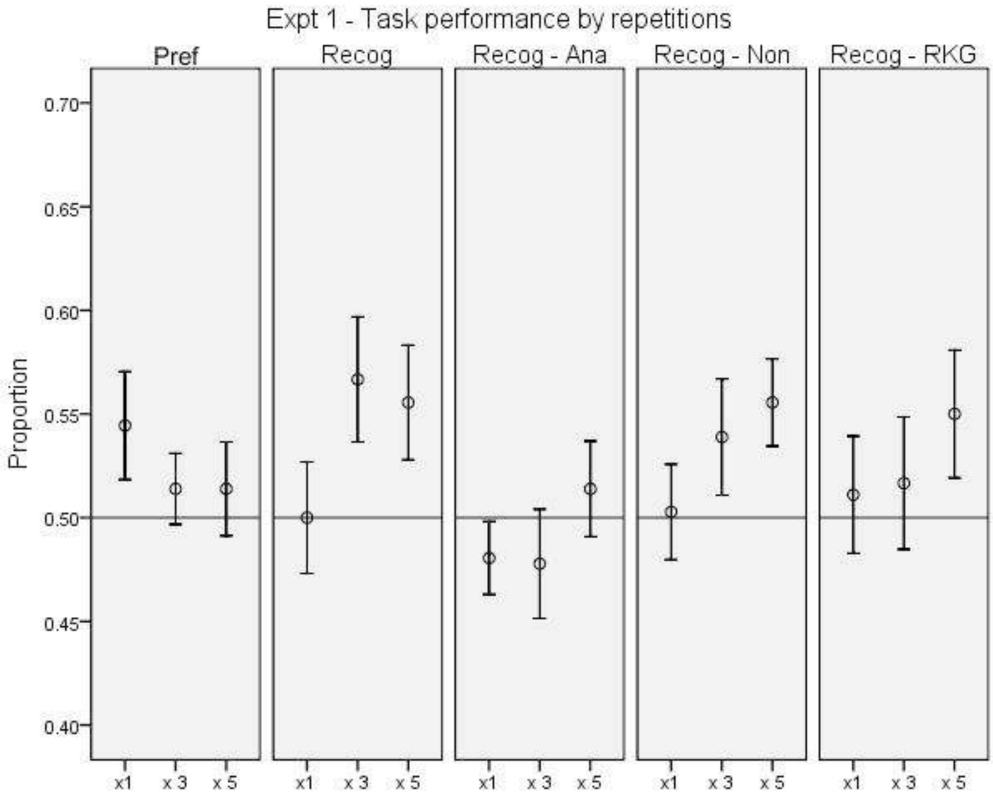
Experiment 1B was identical, except that the subjects were asked to perform a recognition judgement instead of a preference judgement. No detailed instructions were given; participants were simply asked which picture they recognised from each pair.

Section 1.3. Results

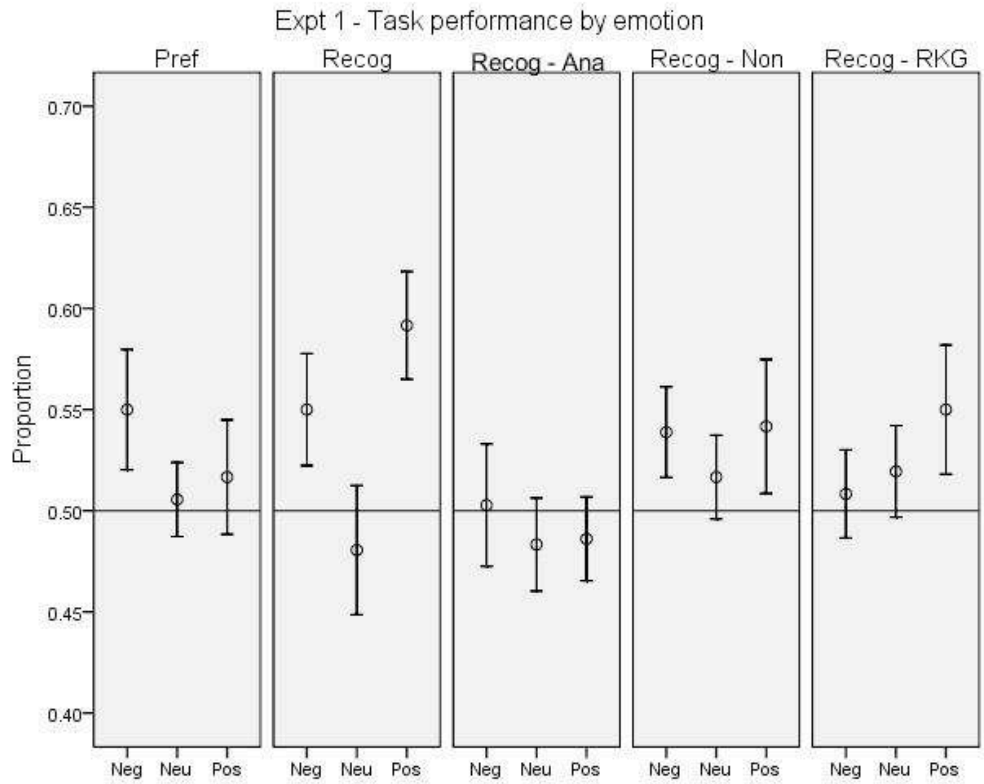
Firstly, we examined the probabilities of selecting the old item in the preference test given that the item had been exposed one, three, or five times in training (see Figure 2.1). Cohen's *d* will be reported as the effect size for all *t* tests. In none of the conditions were the 'old' items selected significantly more often than chance would predict [One: $t(11) = 1.71$, $p = 0.12$, $d = 0.49$; Three: $t(11) = 0.81$, $p = 0.44$, $d = 0.23$; Five: $t(11) = 0.61$, $p = 0.55$, $d = 0.18$]. We performed the same steps in analysing the recognition test. Items presented three times were selected about 7% more often than chance would predict ($t(11) = 2.21$, $p < 0.05$, $d = 0.64$). The selection of items presented five times was approaching statistical significance [$t(11) = 2.01$, $p = 0.07$, $d = 0.58$]. Items presented once were not selected more often than chance would predict [$t(11) < 0.001$, $p = 1.00$, $d = 0$].

Secondly, we conducted an ANOVA to compare the probabilities of selecting the old item when it had a positive, negative or neutral valence and when it was shown one, three or five times. For all ANOVA analyses Mauchly's test of sphericity was conducted and in those cases where the assumptions were not met the Greenhouse-Geisser adjusted *p* values are reported. These will be indicated with degrees of freedom which contain decimal points. Cohen's *f* will be reported as the effect size for all factors and interactions for the ANOVA's. Tukey's Honestly Significant Difference pairwise comparisons were conducted for all significant main effects revealed by the ANOVA's. These are only reported where significant. For brevity the ANOVA values in this chapter only are reported in tabular form (see Table 2.1).

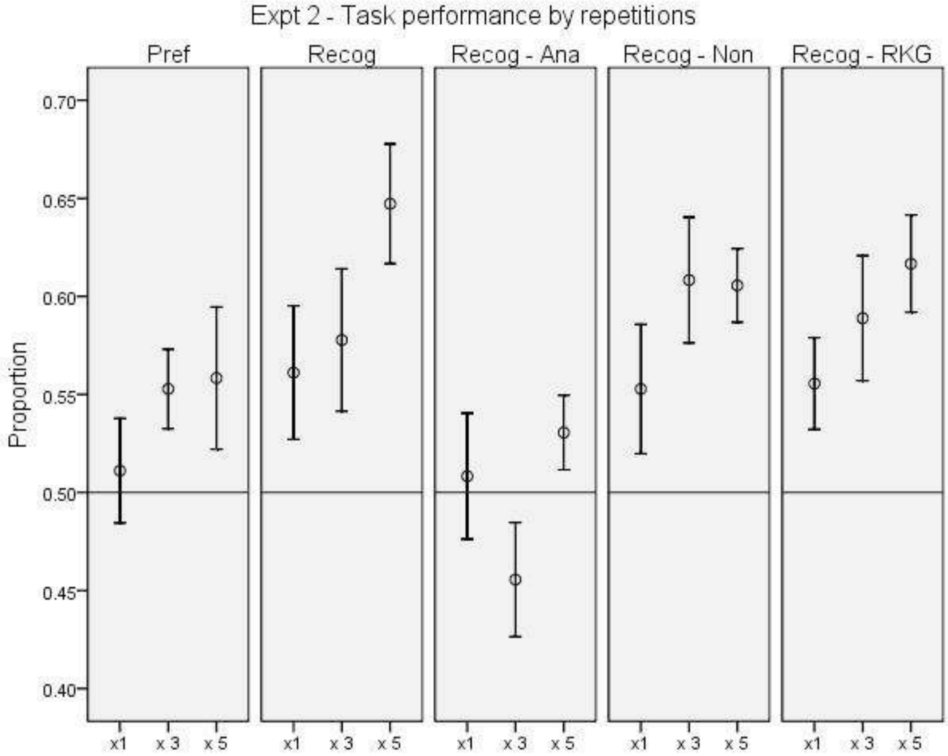
For the preference task, a 3 (emotion) x 3 (repetitions) repeated measures ANOVA found no significant effects for the main effects of emotion block or repetitions, nor for the interaction between emotion block and repetitions. For the recognition task, a 3 (emotion) x 3 (repetitions) repeated measures ANOVA found a significant main effect of emotion block, but not for repetitions or the interaction between emotion block*repetitions. Post hoc analyses revealed that significantly more 'old' photos were selected from the positive than neutral block ($q = 4.15$, $p < 0.05$).

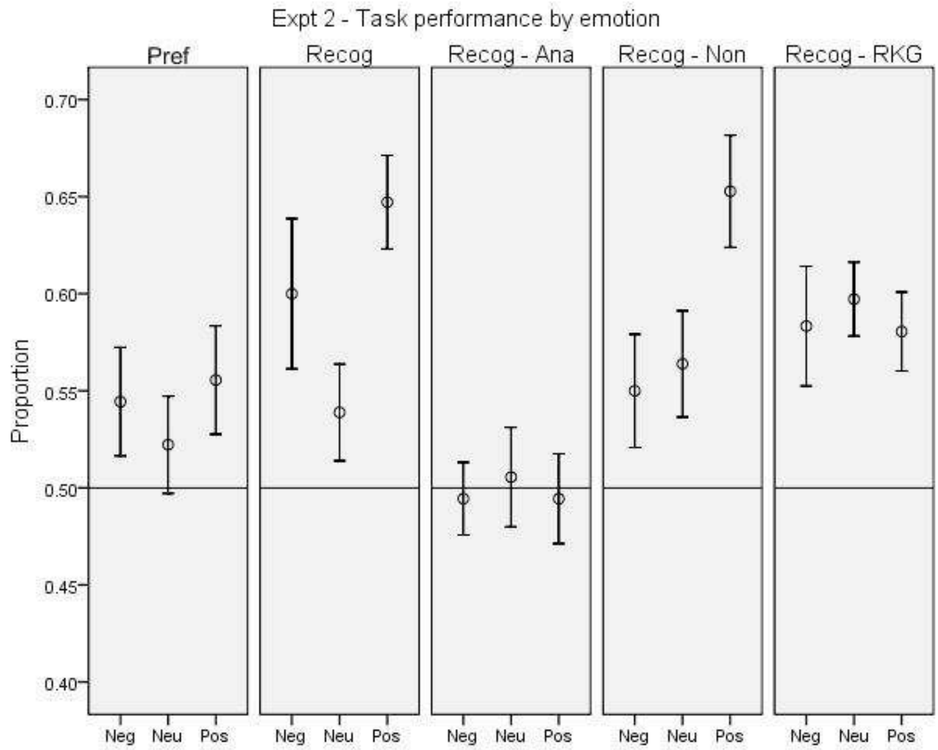


Expt 1 - Task performance by repetitions
Pref
Recog
Recog - Ana
Recog - Non
Recog - RKG
Proportion
0.70
0.65
0.60
0.55
0.50
0.45
0.40
x1
x 3
x 5



Expt 1 - Task performance by emotion
Pref
Recog
Recog - Ana
Recog - Non
Recog - RKG
Proportion
0.70
0.65
0.60
0.55
0.50
0.45
0.40
Neg
Neu
Pos





<u>Figure 2.1. Experiments 1 and 2: Performance by repetitions and emotion for each task (preference, recognition, recognition–analytical, recognition–nonanalytical, recognition–RKG). Error bars show ± 1 S.E. of mean.</u>

Table 2.1: Experiments 1 and 2: Results of ANOVA analysis across condition

Condition	Emotion block	Repetitions	Emotion block *Repetitions
Experiment 1 – Photo Duration 40ms			
Preference	$F_{(2,22)} = 0.91$, MSe = 2.13, $p = .42$, $f = 0.29$	$F_{(2,22)} = 0.96$, MSe = 1.17, $p = .40$, $f = 0.29$	$F_{(4,44)} = 1.34$, MSe = 2.27, $p = .27$, $f = 0.35$
Recognition – Straightforward	**$F_{(2,22)} = 4.39$, MSe = 2.59, $p < .05$, $f = 0.63$**	$F_{(2,22)} = 1.91$, MSe = 2.41, $p = .17$, $f = 0.42$	$F_{(4,44)} = 0.64$, MSe = 2.80, $p = .64$, $f = 0.24$
Recognition – Analytic	$F_{(2,22)} = 0.14$, MSe = 2.90, $p = .87$, $f = 0.11$	$F_{(2,22)} = 0.63$, MSe = 2.29, $p = .54$, $f = 0.24$	$F_{(4,44)} = 0.33$, MSe = 2.05, $p = .86$, $f = 0.17$
Recognition – Nonanalytic	$F_{(2,22)} = 0.24$, MSe = 2.84, $p = .79$, $f = 0.15$	$F_{(2,22)} = 1.11$, MSe = 2.39, $p = .35$, $f = 0.32$	$F_{(4,44)} = 0.30$, MSe = 3.16, $p = .88$, $f = 0.17$
Recognition – RKG	$F_{(2,22)} = 0.95$, MSe = 1.77, $p = .40$, $f = 0.29$	$F_{(2,22)} = 0.51$, MSe = 3.14, $p = .61$, $f = 0.21$	$F_{(4,44)} = 1.10$, MSe = 2.35, $p = .37$, $f = 0.32$
Experiment 2 – Photo Duration 80ms			
Preference	$F_{(2,22)} = 0.58$, MSe = 1.77, $p = .57$, $f = 0.23$	$F_{(2,22)} = 1.08$, MSe = 2.23, $p = .36$, $f = 0.31$	$F_{(4,44)} = 0.83$, MSe = 2.82, $p = .51$, $f = 0.27$
Recognition – Straightforward	**$F_{(2,22)} = 4.39$, MSe = 2.42, $p < .05$, $f = 0.63$**	$F_{(2,22)} = 2.03$, MSe = 3.70, $p = .16$, $f = 0.43$	$F_{(4,44)} = 0.16$, MSe = 2.51, $p = .96$, $f = 0.12$
Recognition –	$F_{(2,22)} = 0.06$, MSe =	$F_{(2,22)} = 1.50$, MSe =	$F_{(2.5,27.2)} = 2.12$, MSe

Analytic	2.31, p = .94, f = 0.08	3.57, p = .25, f = 0.37	= 3.50, p = .13, f = 0.44
Recognition – Nonanalytic	**$F_{(2,22)}$ = 7.48, MSe = 1.50, p < .01, f = 0.82**	$F_{(2,22)}$ = 2.26, MSe = 1.56, p = .13, f = 0.45	$F_{(4,44)}$ = 0.45, MSe = 2.64, p = .78, f = 0.20
Recognition – RKG	$F_{(2,22)}$ = 0.16, MSe = 1.83, p = .86, f = 0.12	$F_{(2,22)}$ = 1.28, MSe = 2.64, p = .30, f = 0.34	$F_{(4,44)}$ = 1.27, MSe = 2.54, p = .30, f = 0.34

Section 1.4. Discussion

In experiment 1A we found no evidence for preference of items seen previously. In experiment 1B there was evidence of recognition memory with photos presented 3 or 5 times, although this was at a low level with performance about 7% above chance levels. There was no emotional enhancement in the preference task but in the recognition task performance was better for positive than neutral pictures.

Section 2. Experiments 1C and 1D: Analytic and Nonanalytic Recognition

Section 2.1. Introduction

We predict that an emotional enhancement of memory will be seen with a nonanalytic recognition style, but not with analytic recognition style. We also predict that in line with Whittlesea and Price (2001) overall recognition will be greater for nonanalytic than analytic recognition style.

Section 2.2 Method

Design

In these experiments the influence of emotion on judgements of recognition using an analytic and nonanalytic style of retrieval was examined.

Participants

Twelve University of Nottingham students participated in Experiment 1C (Mean age 21.50 years (SD 2.65 yrs); 5 female), and 12 in Experiment 1D (Mean age 19.92 years (SD 1.50 yrs); 6 female).

Materials

The same materials were used as in Experiments 1A and 1B. In the Whittlesea and Price (2001) experiments hairline crosses were used in the analytic and nonanalytic recognition conditions to facilitate the identification of an altered region of the photograph. Whittlesea and Price (2001) demonstrated that it was the differing instructions, and not the hairlines, that were responsible for inducing analytic recognition. Therefore, for ease of comparison of results across experiments, hairline crosses were not used in this experiment.

Procedure

The procedure was identical to that of Experiment 1A, except for the different instructions given to participants during the test phase. In Experiment 1C (analytic recognition) participants were told that, from each pair, both photos had been presented previously but one of the photos had been altered from its previous presentation. They should select the photo they thought had been altered (by pressing ‘1’ or ‘9’), and then point and ‘click’ with the mouse cursor in the region of the photo which they thought had been altered. Therefore, the correct answer was the photograph which they thought was different from the initial presentation. Relative to the other experiments reported the response given in Experiment 1C would indicate the photograph participants did not remember seeing before and therefore the scores were reversed. In Experiment 1D (nonanalytic recognition) participants were told that neither photo, from each pair, had been shown previously but a photo from the same category as each of the test photos had been shown previously (e.g. another bird). They should select the photo that was globally similar to the photo of the same category that was shown earlier (by pressing ‘1’ or ‘9’).

Section 2.3. Results

For analytic recognition, in none of the conditions were the ‘old’ items selected significantly more often than chance would predict [One: $t(11) = 1.10$, $p = .29$, $d = -0.32$; Three: $t(11) = 0.84$, $p = .42$, $d = -0.24$; Five: $t(11) = 0.60$, $p = .56$, $d = 0.17$]. For nonanalytic recognition, items presented five times were selected about 6% more often than would be predicted by chance ($t(11) = 2.64$, $p < .05$, $d = 0.76$). Items presented once or 3 times were not selected significantly more often than chance would predict [Once: $t(11) = 0.12$, $p = .91$, $d = 0.03$; Three: $t(11) = 1.39$, $p = .19$, $d = 0.40$].

For the analytic recognition test and the nonanalytic recognition test, the 3 (emotion) x 3 (repetitions) repeated measures ANOVAs found no significant main effects of emotion block or repetitions and the interaction between emotion block and repetitions was not significant (See Table 2.1 for ANOVA results).

Section 2.4. Discussion

We found evidence of recognition memory in the nonanalytic recognition when photos were shown 5 times, as with the straightforward recognition task this was at a low level at about 5% greater than chance. There was no evidence of recognition memory with analytic recognition. This is consistent with our predictions that nonanalytic recognition would be greater than analytic recognition. In contrast to what we were expecting we found no evidence of an emotional enhancement of memory in analytic or nonanalytic recognition. However, this may have been due to the very low levels of recognition memory.

Section 3. Experiment 1E: Recognition followed by Remember / Know / Guess judgement

Section 3.1. Introduction

In an attempt to uncover more of the differences between memory for emotional and neutral material we examined recognition followed by a Remember / Know / Guess (RKG) judgement. Similarly to the analysis of Ochsner (2000) we used the Yonelinas, Kroll, Dobbins, Lazzara, & Knight (1998) model of recognition memory to examine recollection and familiarity. We added the Guess category in line with other research using the Remember-Know paradigm with two alternative forced choice tests (Bastin & Van der Linden, 2003).

Section 3.2. Method

Design

In this experiment we investigated the influence of emotion on recognition and on a subsequent Remember, Know, Guess judgement.

Participants

Twelve University of Nottingham students participated in Experiment 1E (Mean age 24.42 years (SD 7.92 yrs); 7 female).

Materials

The same materials were used as in Experiments 1A-D.

Procedure.

The procedure was identical to that of Experiment 1A, except for the different instructions given to participants during the test phase. Participants were asked to perform a recognition judgement, for which instructions were the same as Experiment 1B. After each recognition judgement participants were asked to indicate their level of awareness of the memory by indicating whether they Remember / Know / Guess that they recognise the photo. Participants then indicated 'Remember' if their recognition was accompanied by some recollective experience, 'Know' if the photograph was familiar but they had no recollective experience, or 'Guess' if the photograph was not familiar nor was it accompanied by some recollective experience but they guessed that they had seen it earlier. They indicated this by pressing 'R', 'K' or 'G' on the keyboard. Participants were also given written instructions explaining how to differentiate between RKG (Bastin & Van der Linden, 2003). Their understanding of these instructions was checked and they were asked to justify their RKG judgement following the two example tasks.

Section 3.3. Results

For the recognition test, which was followed by a RKG judgement, none of the 'old' items were selected significantly more often than chance would predict [One: $t(11) = 0.39$, $p = .70$, $d = 0.11$; Three: $t(11) = 0.52$, $p = .61$, $d = 0.15$; Five: $t(11) = 1.62$, $p = .13$, $d = 0.47$]. A 3 (emotion) x 3 (repetitions) repeated measures ANOVA found no significant main effects for the main effects of emotion block or repetitions and the interaction between emotion block and repetitions was not significant.

We analysed the Remember / Know / Guess responses by conducting an ANOVA on each of the different types of responses separately with three factors of Correct or Incorrect, Emotion block and Number of repetitions. We analysed Recollection and Familiarity (as per Yonelinas et al., 1998) by emotion block and number of repetitions. However, as recognition did not exceed chance it is difficult to interpret these results and therefore they are not reported here. (Results of these analyses are given in Appendix 2.2).

Section 3.4. Discussion

No evidence of recognition memory was found and there was no evidence of emotional enhancement of memory.

Section 4. General Discussion

Overall performance was lower than that observed by Whittlesea and Price (2001) and there were not many emotional effects. This may be because the stimuli in our experiment were more difficult to encode. Nevertheless, our recognition task results are consistent with Whittlesea and Price (2001) in that, we do have greater recognition in the nonanalytic and straightforward recognition conditions than in the analytic recognition condition. It appears that making a Remember / Know / Guess judgement may impair memory and lead to an analytic stance as there was no recognition in this condition. We did not find a preference for previously shown stimuli, which may suggest that with emotional stimuli a preference task changes from a nonanalytic style of recognition task to an analytic task. However, this was not a prediction tested by Whittlesea and Price (2001). In Experiment 2 we aimed to improve recognition above chance levels.

Section 5. Experiments 2A and 2B: Preference and Recognition

Section 5.1. Introduction

For Experiment 2 we doubled the exposure duration of the photographs in the training phase that was used by Whittlesea & Price (2001) to 80msec and we expected that this would improve memory dramatically over the number of repetitions. We repeated the experiments from Experiment 1 with a new set of participants and an increased length of photo exposure during the training phase, in all other respects Experiments 1 and 2 were identical.

With increased photo duration we expected to see the same pattern of results as in Experiments 1A and 1B, but with greater levels of performance.

Section 5.2. Method

Participants

Twelve University of Nottingham students participated in Experiment 2A (Mean age 20.58 years (SD 1.16 yrs); 4 female), and 12 in Experiment 2B (Mean age 21.00 years (SD 3.28 yrs); 9 female).

Procedure

An identical procedure was used for Experiments 2A and 2B, as for Experiments 1A and 1B, except that the length of photo exposure in the training phase was extended to 80 msec.

Section 5.3. Results

In the preference test significantly more of the ‘old’ items were selected than would be predicted by chance for those photos that were shown three times ($t(11) = 2.60$, $p < .05$, $d = 0.75$). However, those photos shown once, or five times were not significantly more likely to be selected than by chance [One: $t(11) = 0.42$, $p = .69$, $d = 0.12$; Five: $t(11) = 1.61$, $p = .14$, $d = 0.46$] (See Figure 2.1). In the recognition test photos that were shown once were not more likely to be selected than chance [$t(11) = 1.80$, $p = .10$, $d = 0.52$]. Those that were shown three times were approaching significance [$t(11) = 2.14$, $p = .06$, $d = 0.62$] and those that were shown 5 times were significantly more likely than chance to be selected ($t(11) = 4.82$, $p < .001$, $d = 1.39$).

For the preference test, the 3 (emotion) x 3 (repetitions) repeated measures ANOVA found no significant effects for the main effects of emotion block and repetitions nor for the interaction between emotion block*repetitions (See Table 2.1 for ANOVA results). For the recognition test, the 3 (emotion) x 3 (repetitions) repeated measures ANOVA found a significant main effect of emotion block but not of repetitions and there was no significant interaction between emotion block* repetitions. Post hoc analyses for emotion block revealed that significantly more 'old' photos were selected from the positive than from the neutral group ($q = 4.18$, $p < 0.05$).

Section 5.4 Discussion

We found some evidence of preference for items seen previously, but only when these had been shown 3 times, not when they were shown once or 5 times. Even though there is one significant result for the preference task it appears that the overall trend from Experiments 1A and 2A is towards little or no preference for previously exposed items. Further analysis found no effect of emotion block or number of repetitions in the accuracy of selecting 'old' items in the preference task. In the recognition test we found evidence of memory for items that had been seen previously when they had been shown 5 times, with a trend in the same direction for those shown 3 times. An emotional enhancement of memory was found with photos from the positive block more likely to be recognised than those from the neutral block. The results for the recognition tests were in the same direction, and of the same effect size for emotion, to those obtained with the shorter 40 msec photo duration.

Section 6. Experiments 2C and 2D: Analytic and Nonanalytic Recognition

Section 6.1. Introduction

It was expected that we would observe the same pattern of results here as those found in experiments 1C and 1D.

Section 6.2. Method

Participants.

Twelve University of Nottingham students participated in Experiment 2C (Mean age 21.67 years (SD 2.46 yrs); 6 female), and 12 in Experiment 2D (Mean age 19.92 years (SD 1.16 yrs); 10 female).

Procedure.

An identical procedure was used for Experiments 2C and 2D, as for Experiments 1C and 1D, except that the length of photo exposure in the training phase was extended to 80 msec.

Section 6.3. Results

For analytic recognition in none of the conditions were the 'old' photos more likely to be selected than chance [One: $t(11) = 0.26$, $p = .80$, $d = 0.07$;

Three: $t(11) = 1.53$, $p = .16$, $d = -0.44$; Five: $t(11) = 1.61$, $p = .14$, $d = 0.46$]. For nonanalytic recognition photos shown once were no more likely than chance to be selected [$t(11) = 1.60$, $p = .14$, $d = 0.46$]. However, photos shown three or five times were more likely to be selected than chance (Three: $t(11) = 3.38$, $p < .01$, $d = 0.97$; Five: $t(11) = 5.64$, $p < .001$, $d = 1.63$).

For analytic recognition, the 3 (emotion) x 3 (repetitions) repeated measures ANOVA found no significant effects for the main effects of emotion block and repetitions nor for the interaction between emotion block*repetitions. For nonanalytic recognition, the 3 (emotion) x 3 (repetitions) repeated measures ANOVA found there was a significant effect of emotion block but not of repetitions nor of the interaction between emotion block*repetitions. Post hoc analyses for emotion block revealed that significantly more 'old' photos were selected from the positive than from the neutral group ($q = 4.36$, $p < .05$), and from the positive than from the negative group ($q = 5.04$, $p < .01$).

Section 6.4. Discussion

For analytic recognition, results were similar to those found with the shorter duration. There was still no evidence of recognition, and no effect of emotion block or number of photo repetitions. With nonanalytic recognition the expected emotional enhancement of memory that we did not find at 40 msec, appeared with a photo exposure of 80 msec. There was an emotional enhancement of memory for positive over neutral and negative stimuli.

Section 7. Experiment 2E: Recognition followed by Remember / Know / Guess judgement

Section 7.1. Introduction

In Experiment 1E performance overall did not exceed chance and it was not possible to meaningfully examine the RKG responses. With the increased exposure duration used in Experiment 2 we expect recognition to be greater than chance and therefore allow analysis of the RKG responses.

Section 7.2. Method

Participants.

Twelve University of Nottingham students participated in Experiment 2E (Mean age 25.83 years (SD 9.44 yrs); 4 female).

Procedure.

An identical procedure was used for Experiments 2E, as for Experiments 1E, except that the length of photo exposure in the training phase was extended to 80 msec.

Section 7.3. Results

With recognition followed by a Remember / Know / Guess judgement participants were more likely to select the ‘old’ photos whether they had seen these one, three or five times (One: $t(11) = 2.38$, $p < .05$, $d = 0.69$; Three: $t(11) = 2.79$, $p < .05$, $d = 0.81$; Five: $t(11) = 4.71$, $p < .001$, $d = 1.36$). A 3 (emotion) x 3 (repetitions) repeated measures ANOVA found no significant main effects of emotion block and repetitions and no significant interaction between emotion block and repetitions.

We analysed the Remember / Know / Guess responses by conducting an ANOVA on each of the different types of responses separately with 3 factors of accuracy (correct or incorrect), emotion block (negative, neutral, positive) and number of repetitions (presented once, three or five times) (For ANOVA values see Table 2.2, for means see Tables 2.3 and 2.4).

For the ‘remember’ responses the main effects of repetitions and accuracy were significant but that of emotion block was not. The interaction between accuracy and repetitions was significant but none of the other interactions were significant. Post hoc comparisons revealed that significantly more ‘remember’ responses were made for photos shown 5 times than 3 times ($q = 6.60$, $p < .001$), and for those shown 5 times than once ($q = 5.31$, $p < .01$). Further examination of the significant interaction revealed significantly more correct ‘remember’ responses were given when the photos were shown 5 times than one time ($q = 8.32$, $p < .001$) and 5 times than 3 times ($q = 5.48$, $p < .01$). When examining the interaction according to the number of repetitions, it was found that significantly more correct than incorrect ‘remember’ responses were given when photos were shown 5 times ($q = 6.87$, $p < .001$) and when shown 3 times ($q = 4.02$, $p < .05$).

Table 2.2. Experiment 2: Results of separate ANOVA analysis on Remember/Know/Guess responses

	Remember	Know	Guess
Emotion block	$F_{(2,22)} = 0.24$, MSe = 1.02, $p = .79$, $f = 0.15$	$F_{(2,22)} = 0.49$, MSe = 1.22, $p = .62$, $f = 0.21$	$F_{(2,22)} = 0.96$, MSe = 1.65, $p = .40$, $f = 0.29$
Repetitions	**$F_{(2,22)} = 12.25$, MSe = 0.67, $p < .001$, $f = 1.06$**	$F_{(1.2,12.8)} = 0.87$, MSe = 2.49, $p = .38$, $f = 0.28$	**$F_{(2,22)} = 6.84$, MSe = 1.13, $p < 0.01$, $f = 0.79$**
Accuracy	**$F_{(1,11)} = 22.96$, MSe = 0.99, $p < .001$, $f = 1.44$**	**$F_{(1,11)} = 27.04$, MSe = 1.24, $p < .001$, $f = 1.57$**	$F_{(1,11)} = 2.22$, MSe = 2.27, $p = .17$, $f = 0.45$
Emotion block*Repetitions	$F_{(4,44)} = 1.40$, MSe = 0.61, $p = .25$, $f = 0.36$	$F_{(2.3,25.4)} = 1.49$, MSe = 1.54, $p = .25$, $f = 0.37$	$F_{(4,44)} = 1.16$, MSe = 0.81, $p = .34$, $f = 0.32$
Emotion block*Accuracy	$F_{(1.2,13.1)} = 2.65$, MSe = 1.28, $p = .09$, $f = 0.49$	$F_{(2,22)} = 0.02$, MSe = 1.90, $p = .98$, $f = 0.04$	$F_{(2,22)} = 0.27$, MSe = 1.93, $p = .77$, $f = 0.16$
Repetitions*Accuracy	**$F_{(2,22)} = 4.62$, MSe = 0.97, $p < .05$, $f = 0.65$**	$F_{(2,22)} = 1.77$, MSe = 1.96, $p = .19$, $f = 0.40$	$F_{(2,22)} = 0.68$, MSe = 2.85, $p = .52$, $f = 0.25$
Emotion*Repetitions*Accuracy	$F_{(4,44)} = 1.57$, MSe = 0.52, $p = .20$, $f = 0.38$	$F_{(4,44)} = 1.82$, MSe = 1.45, $p = .14$, $f = 0.41$	$F_{(4,44)} = 2.29$, MSe = 2.47, $p = .07$, $f = 0.46$

Table 2.3. Experiment 2: Probabilities of Hits or False Alarms to a Remember / Know / Guess judgement, Recollection and Familiarity in a two alternative forced-choice test (by number of training presentations)

Number of	Remember		Know		Guess		Rec	Fd'
Repetitions	Hits	FAs	Hits	FAs	Hits	FAs		
One	.05	.04	.19	.16	.31	.24	.01	.13
Three	.09	.03	.19	.11	.30	.28	.07	.28
Five	.17	.05	.22	.10	.23	.23	.12	.48

NB: Rec = Recollection; Fd' = Familiarity – both calculated according to Yonelinas et al (1998)

Table 2.4. Experiment 2: Probabilities of Hits or False Alarms to a Remember / Know / Guess judgement, Recollection and Familiarity in a two alternative forced-choice test (by emotion block)

Emotion	Remember		Know		Guess		Rec	Fd'
Block	Hits	FAs	Hits	FAs	Hits	FAs		
Positive	.11	.05	.21	.13	.26	.24	.06	.20
Neutral	.12	.02	.19	.12	.29	.27	.10	.39
Negative	.09	.05	.20	.12	.29	.24	.03	.26

NB: Rec = Recollection; Fd' = Familiarity – both calculated according to Yonelinas et al (1998)

For the ‘know’ responses the main effect of accuracy was significant but the main effects of emotion block and repetitions, and the interactions between the factors, were not significant.

For the ‘guess’ responses the main effect of repetitions was significant but the main effects of accuracy and emotion block, and the interactions between the factors, were not significant. Post hoc comparisons revealed that significantly more ‘guess’ responses were given for photos shown 3 times than 5 times ($q = 4.98$, $p < .01$) and for those shown once than five times ($q = 3.87$, $p < .05$).

We calculated Recollection according to Yonelinas et al (1998), disregarding the Guess responses. We analysed Recollection with a 3 (number of repetitions) x 3 (emotion block) repeated measures ANOVA (see Table 2.5 for the ANOVA results). There was no significant main effect for the factor of emotion but there was for repetitions although not for the interaction. Post hoc analysis revealed that there was significantly greater recollection for photos that had been presented 5 times than those presented once ($q = 4.41$, $p < .05$). We analysed Familiarity (Fd’) across the same factors with a 3 (number of repetitions) x 3 (emotion block) repeated measures ANOVA. There were no significant main effects for the factors of emotion block and number of repetitions nor for the interaction.

Table 2.5. Experiment 2: Separate ANOVA analysis on Recollection and Familiarity

	Recollection	Familiarity
Emotion block	$F_{(1.2,12.8)}$ = 2.38, MSe = 0.04, p = .15, f = 0.46	$F_{(2,22)}$ = 0.08, MSe = 1.67, p = .93, f = 0.08
Repetitions	**$F_{(2,22)}$ = 4.883, MSe = 0.03, p < .05, f = 0.67**	$F_{(1.4,15.0)}$ = 0.28, MSe = 2.87, p = .76, f = 0.16
Emotion block*Repetitions	$F_{(4,44)}$ = 1.17, MSe = 0.02, p = .34, f = 0.33	$F_{(4,44)}$ = 1.13, MSe = 1.30, p = .35, f = 0.32

Section 7.4. Discussion

In contrast to the results found with a photo exposure of 40 msec, at 80 msec, there was evidence of recognition memory for photos that had been shown once, three or five times. Nevertheless, even though the floor effect from Experiment 1E was removed, there remained no evidence of an emotional enhancement of recognition memory in this task. Analysis of the Remember / Know / Guess responses revealed that after correct recognition of an item more 'remember' responses were given to items which were shown with more repetitions. There were no significant effects revealed for the Know differences, as expected from the findings of Ochsner (2000). After correct recognition of an item a 'guess' response was more likely with items which were shown with fewer repetitions. No emotional enhancement was found for the numbers of Remember / Know / Guess responses, Recollection nor Familiarity. This was in contrast to the findings of Ochsner (2000) who found that recollection was enhanced for negative and positive stimuli.

Section 8. Experiment 2 - General Discussion

The same pattern of results was found with increased duration of photo exposure, as with a shorter duration, with the exception that evidence of recognition memory when followed by a RKG judgement was only found with the longer photo exposure. No preference for previously exposed stimuli was found. Better recognition was found for positive stimuli in a straightforward recognition and nonanalytic recognition task. There was recognition when followed by RKG judgement but no effect of emotional enhancement. No recognition was found with an analytic recognition task.

Section 9. Chapter Discussion

Three key findings have emerged from these studies. Firstly, we have replicated Whittlesea & Price's (2001) findings showing that retrieval strategy is important in memory for briefly presented stimuli. Secondly, we have found emotional differences for briefly presented stimuli, when these appear they tend to be an advantage for positive stimuli but these only seem to appear when participants are engaged in a nonanalytic style of processing. Thirdly, a commonly used procedure, the Remember-Know-Guess paradigm may affect how participants do a task in a way which affects emotion. These three issues will now be discussed in detail.

With photo exposure of 80 msec we found an emotional (positive) advantage in traditional recognition. In addition we found the same with nonanalytic processing at retrieval. This suggests that, as argued by Whittlesea and Price (2001), nonanalytic processing styles at retrieval are also used during traditional recognition tasks. This positive enhancement in memory seems to depend on nonanalytic processing. The use of analytic processing at retrieval seems to remove or reduce this effect of increased memory for positive stimuli.

Despite the identical presentation of stimuli we only found evidence of an overall emotional enhancement bias in some conditions. This would suggest that whether an emotional enhancement of memory will be observed depends on the retrieval processing strategy encouraged by the retrieval task. These findings are consistent with the idea that the process of retrieving memories is different for emotional than non-emotional stimuli (e.g. Maratos & Rugg, 2001; Smith et al., 2004).

We found an emotional enhancement for positive, but not negative, stimuli in comparison to neutral stimuli. This is in contrast to findings of some previous studies which have found an advantage for negative stimuli, but not positive (Ochsner, 2000) and in contrast to other studies which have found an advantage for both pleasant and unpleasant stimuli (Dewhurst & Parry, 2000; Dolcos et al., 2005). Some of the differences in patterns of emotional enhancement of memory may be due to the different time frames involved. We tested recognition immediately after exposure to the photographs, Ochsner (2000) tested recognition after 2 weeks, and Dolcos et al. (2005) tested recognition after 1 year. However, Dewhurst & Parry (2000) found an emotional enhancement of memory after only a 10 minute delay. The length of time for which our stimuli were presented at encoding may explain our lack of an enhancement of memory for negative stimuli. Kensinger, et al (2006) found an enhancement of memory for negative, over neutral, stimuli at 1000 ms and 500 ms but not at 250 ms.

Presentation of stimuli in blocked lists of emotional valence in contrast to mixed lists of emotional valence may have influenced our findings. Dewhurst & Parry (2000) found that more Remember responses were given to emotional than neutral words when stimuli were presented in mixed lists, but that this enhancement disappeared when stimuli were presented in blocked lists of emotional or neutral words. However, we did find a better memory for positive emotional stimuli in some conditions with blocked lists of emotional stimuli.

Positive stimuli may have benefited from nonanalytic processing at retrieval more than negative stimuli due to similarity to the heuristic styles of information processing that are often seen with positive moods. This is in contrast to the analytic and data-driven modes of information processing that are seen with negative emotions (Levine & Pizarro, 2006). Emotional stimuli may engender a mood which may then affect retrieval style. Bodenhausen et al. (1994) found that individuals who had been induced to feel happy rendered more stereotypic judgements than did those in a neutral mood. Similar findings have been demonstrated with studies of memory. Phaf & Rotteveel (2005) found that induced positive affect led to a more liberal recognition bias of test words, whereas negative affect led to more cautious tendencies without any effect on accuracy of recognition memory. Levine & Bluck (2004) found similar results with memory for a real world event. Participants who were happy about the event having occurred had a lower threshold for judging that specific details of the event had occurred than participants who had a negative reaction to the original event (Levine & Bluck, 2004). Buchanan (2007) found that memories are also influenced by the emotion experienced during memory retrieval. It is possible that participants in this study had a positive mood induced whilst viewing the positive block of photos which, may have led them to be more successful in using nonanalytic processing at retrieval for the positive block of photos. When participants were encouraged to use analytic processing at retrieval this may have inhibited their feelings of emotion when looking at the photos. This may explain why no emotional enhancement of memory was found in the analytic style at retrieval or when recognition was followed by a RKG judgement.

We found no emotional differences in the RKG task either in the overall recognition or subsequent RKG response. Our lack of finding an emotional effect in the recognition task which is subsequently followed by an RKG response is consistent with previous research by Dougal & Rotello (2007) who also found no effect of emotion on recognition accuracy. However, our RKG findings are not consistent with that aspect of Dougal & Rotello's findings as they did find an emotional effect on the subjective experience of recollection as measured by the RKG responses. It is surprising that we have not found any emotional differences in the RKG responses as others have found, however these tasks have all had longer duration times and it is likely that participants did more extensive encoding and paid more attention to the stimuli in these tasks. Our very short presentation duration may have led to the lack of RKG differences in this research, this is in comparison to durations of 3 seconds (Dougal & Rotello, 2007).Research using a one-step Remember-Know-New paradigm, instead of the two-step paradigm used here, has also found an emotional enhancement of accuracy of recognition memory after 2 second exposures (e.g. Ochsner, 2000).

It is possible that the act of making an RKG judgement lead participants to engage in a more analytical style of processing at retrieval, thereby blocking or reducing any advantage that may be available from emotional stimuli. These findings are consistent with those of Dahl et al. (2006) who found no difference in recognition between positive and negative pictures. Although, they did find a valence dependent difference in the RKG responses with a greater proportion of 'remember' responses for negative pictures.

It has been suggested that differences in recognition found with emotional stimuli are solely due to response biases, rather than reflecting true differences in recollection (Dougal & Rotello, 2007). However, we found no evidence of response bias in the RKG responses given to emotional stimuli in this experiment. It is possible that the use of 2AFC decreased the probability of participants being susceptible to response bias. Aupeé (2007) found lower recollection of negative and positive, than neutral, pictures when measuring recollection of a targeted piece of information, such as when the stimulus was presented. This particular task may have lead participants to use an analytic style at retrieval and thus block or reduce any emotional enhancement.

Previous research (e.g. Dewhurst & Parry, 2000) found that emotional differences in a Remember-Know paradigm were only revealed when a mixed list of emotional and non-emotional stimuli were used, in contrast to the blocked lists of stimuli used in these experiments. However, more recent studies have demonstrated emotional enhancement in memory even with blocked lists of emotional and non-emotional stimuli (e.g. Talmi, et al., 2007). The use of blocked lists is unlikely to explain the difference in our findings as we did find evidence of emotional differences in recognition with other retrieval conditions. It may be that the use of blocked lists could have explained a reduced effect of emotion on RKG responses, but it is unlikely that this could explain a complete eradication of any effect of emotion.

There are differences in the format of the recognition test between this experiment and that used in other research with which our findings are inconsistent. Ochsner (2000) used a Yes-No recognition task, whereas we used a two alternative forced choice recognition task. However, Kroll, Yonelinas, Dobbins, & Frederick (2002) compared both these paradigms and found that memory accuracy did not differ across the tests and they therefore concluded that both tests relied on the same underlying memory processes.

The preference task was included to allow a direct comparison with Whittlesea and Price (2001). We failed to find any preference for previously viewed stimuli. This is in contrast to Whittlesea and Price (2001). This difference may be due to their use of non-emotional stimuli which may have meant that the only possible reason why participants prefer one picture over another was whether or not they had seen the picture before. It is possible that with emotionally relevant stimuli participants may have had real preferences for particular pictures which may have overridden any experimental manipulations of fluency caused by pre-exposure to stimuli. Research with excerpts of music which evoke positive or negative emotions has successfully demonstrated an effect of repeated exposure on preference of the stimuli (Witvliet & Vrana, 2007), however, preference for pictures may be less malleable.

In conclusion, these results support studies showing an emotional enhancement of memory with positive stimuli. The idea that emotional enhancement can be influenced by retrieval is important in relation to inconsistencies in previous studies. We found emotional enhancement using nonanalytic, but not analytic, processing strategies at retrieval. One particular concern is that making an RKG judgement may change the processing strategy used at retrieval and this may hide or reduce any enhancements of positive material.

Chapter 3. Methodologies to investigate the influence of emotion on memory

Experimental design and methodology can have an impact on the relationship uncovered between different cognitive processes, as highlighted in Chapter 2. In the experiments reported in Chapter 2 an emotional influence was only found when recognition was measured by certain tasks. It is important to establish whether these effects reflect generalisable differences in cognitive processing or whether they are specific to the experimental design. In this chapter the impact of different methodologies to assess memory and induce emotion are investigated.

Section 1. Experiment 3: Do Remember/Know/Guess judgements change the process of retrieval and block the emotional enhancement seen with a simple test of recognition memory?

Section 1.1. Introduction

An investigation of recognition memory and emotion in Experiment 2 found that asking participants to follow recognition with a Remember/Know/Guess judgement blocked the emotional enhancement of recognition memory that was seen when participants were not required to make any additional judgements. With a simple recognition judgement we found a significant improvement of recognition memory for positive photographs, when compared to neutral and negative photographs. Following a RKG judgement there was evidence of recognition memory, but no difference in levels of memory between the positive, neutral or negative photographs. From Experiment 2 we proposed that making a RKG judgement induced participants to use an analytical, rather than nonanalytical, processing strategy at the time of retrieval, thereby eliminating the emotional enhancement of memory.

In this experiment we further investigate the effect that the RKG task has on blocking emotional enhancement of memory by conducting a within-participants design to increase statistical power and create an experimental paradigm which could be used to viably investigate this phenomenon, without the very large numbers of participants required in Experiments 1 and 2. We will compare the emotional influence on memory in a straightforward task of recognition, recognition followed by a RKG judgement and recognition followed by another judgement. Another aim of this experiment is to examine whether any subsequent judgement would block emotional enhancement of memory, or whether this is a phenomenon specific to the RKG task.

Previous research has found that emotional enhancement of memory has differed depending on the judgement used to qualify a recognition task. Dahl et al. (2006) used IAPS photos and asked participants to encode positive and negative photos by viewing a matrix of 4 photographs and identifying the one positive / negative photo presented with 3 neutral photographs. Participants then viewed all of the photos from the encoding phase separately and after identifying a photo as having appeared in the preceding encoding phase they made either a Remember/Know/Guess judgement or a confidence judgement. When participants made a RKG judgement there was no difference in the recognition performance for positive or negative photos. However, when participants made a confidence judgement there was significantly improved performance for negative, than positive, photographs. Participants were more confident about their judgements of negative than positive photographs, and gave more remember responses for negative than positive photographs.

The emotional enhancement in Remember responses found by Dahl et al. (2006) is in a similar direction to other research examining Remember/ Know judgements with emotional stimuli which also found an advantage for negative stimuli (e.g. Ochsner, 2000). This is in contrast to the findings from Experiment 1 and 2, where an advantage was found for positive stimuli alone. This may be due to methodological differences between these studies. In Experiments 1 and 2 we used a two-alternative forced choice recognition judgement, whereas Dahl et al. (2006) and Ochsner (2000) both used a one-step RKN judgement of a single photo. Differences have been found in the proportion of Remember / Know responses given dependent upon whether a one-step Remember, Know, New judgement is made or a two-step judgement where first an old-new judgement is made and then a Remember / Know judgement (Eldridge, Sarfatti, & Knowlton, 2002).

The aim of this study is to examine the effect of task upon memory performance and the influence that emotion has upon memory using a within-participants paradigm, in contrast to the between participants design used in Experiments 1 and 2. We will assess memory performance using the tasks of straightforward recognition and recognition followed by RKG response that were used in Experiments 1 and 2. In addition a condition will be included where the recognition task is followed by a confidence judgement, this will give insight into whether the effects of the additional RKG judgment are due to the performance of any subsequent task, or whether there is something in particular about the RKG task which affects emotion's influence on memory.

We are proposing that the processing style with which information from memory is retrieved to make a recognition judgement will be affected by the knowledge that a subsequent judgement will be required. Specifically, we propose that a judgement such as Remember/Know/Guess has more specific requirements than a judgement of recognition, we argue that it would be most efficient to base the recognition and RKG judgement on the same information and so avoid the need to retrieve the same information from memory twice. Therefore, we argue the judgement of recognition and RKG will be made on the basis of the same piece of information that has been retrieved from memory. In this way, we argue that if the RKG judgement requires an analytical style of processing, this will also be used with the recognition judgement. Specifically, we predict that for straightforward recognition and recognition followed by an RKG response there will be the same pattern of results as in Experiments 1 and 2; that is a positive emotional enhancement of recognition in the former and no emotional enhancement in the latter. When recognition is followed by a confidence judgement we predict that, in line with previous research (e.g. Dahl et al., 2006) there will be emotional enhancement of recognition memory, and that this will be reflected in the ratings of confidence given.

Section 1.2. Method

Design

In this experiment the effects of a factor of emotion with three levels (negative, neutral, positive) and a factor of retrieval task with three levels (recognition memory, recognition memory followed by RKG judgement, recognition memory followed by confidence judgement) on memory performance were examined. Participants were shown negative, neutral and positive stimuli in a within-participant blocked stimuli design. Memory performance was tested using a two-alternative forced choice design to maintain consistency with Experiments 1 and 2.

Participants

Thirty-six participants took part in this experiment (24 female). All were native-English speaking University of Nottingham students or research staff (mean age = 23.9 years, SD = 6.02). Participants received an inconvenience allowance of £2 for their voluntary participation. Participants with a phobia of animals were excluded, as the experimental stimuli contained pictures of several animals.

Materials

Stimuli were 180 colour photographs selected from the IAPS database. The majority of stimuli were those from Experiments 1 and 2 but some additional photographs were selected to allow for matching on low-level visual properties between negative, neutral and positive groups of stimuli. The negative, neutral and positive groups of stimuli in this experiment were matched on low-level visual properties of visual complexity, luminance, RMS contrast, Red, Green and Blue channel saturation, see Table 3.1 (cf. Nummenmaa et al., 2006). These measures of low-level visual properties were obtained using Adobe Photoshop 7.0. There were 2 sets of stimuli used in this experiment to provide a set of targets and distractors for the test phase of the experiment. Emotional arousal, emotional valence and low level visual properties were matched between these two sets (see Appendix 3.1 for means and SD). Stimuli were also matched for whether or not they contained an identifiable face within the photograph.

Stimuli were selected to provide distinct ratings of emotional valence between the positive, neutral and negative groups of stimuli with means (with SD in parentheses) of 7.17 (0.53), 5.01 (0.60) and 3.04 (0.55) respectively. Average ratings of arousal were matched between positive and negative groups of stimuli with means (with SD in parentheses) of 5.11 (0.80) and 5.14 (0.73) respectively with a lower average for the neutral group of 4.70 (0.85).

Table 3.1: Low-level visual properties of photographic stimuli in Negative, Neutral and Positive Emotion Blocks

	Negative	Neutral	Positive
Visual Measure	M (SD)	M (SD)	M (SD)
Luminosity	95.70 (36.17)	94.33 (31.52)	88.00 (33.07)
Complexity	39.67 (10.89)	43.55 (12.86)	39.22 (10.61)
RMS Contrast	1.44 (0.58)	1.73 (1.99)	1.46 (0.73)
Red channel saturation	107.42 (40.08)	105.26 (38.76)	100.05 (34.36)
Green channel saturation	94.85 (35.32)	91.35 (32.17)	84.52 (35.34)
Blue channel saturation	84.75 (33.73)	80.54 (40.41)	73.90 (40.95)

Procedure

At the start of the study participants were shown 10 example photographs to get them used to the speed of presentation of the photographs. Photographs were presented in a Rapid Serial Visual Presentation as in Experiments 1 and 2. Each photo was presented for 120msec, an increase from 80msec in Experiment 2, to ensure sufficient levels of performance as there was no repetition of stimulus presentation as in Experiments 1 and 2.

Experimental stimuli were presented in blocks of positive, negative and neutral stimuli, with the memory task completed directly after presentation of stimuli. This was repeated so that participants performed three different memory tasks (see Figure 3.1). For the first task, e.g. recognition, participants would see a fixation cross for 1 sec and then the RSVP of stimuli would begin showing 10 positive, 10 negative and 10 neutral photographs. The order of photographs within the emotional block was randomised for each participant. Participants were then given instructions for the task. For the recognition task participants were shown a pair of photographs presented side by side, one of each pair had been presented in the preceding RSVP and the other was an emotionally matched item as a distractor. The location of the target photograph (right or left on the screen) was randomised. Participants were told to indicate by key press which photograph they recognised. Firstly, participants completed two examples of the task with two pairs of photographs from the example RSVP. The experimental photographs were then presented in the same order of blocks as in the RSVP (e.g. positive, then negative, then neutral) but the order of photographs within the blocks was randomised. Photographs were presented until a response was made. The second RSVP of 30 photographs was then shown, with the same order of emotional blocks. All aspects of the procedure remained the same apart from new instructions for the second task e.g. recognition followed by a confidence judgement. Participants had to select the photograph they recognised in the same way as for the first block, they had to indicate how confident they were they had seen that photograph previously using a Likert-type scale from 1 (not at all confident) to 5 (very confident). The third RSVP of photographs was then shown. For the third task e.g. recognition followed by a RKG judgement participants were given the same instructions for recognition as in the straightforward recognition task. They were then given detailed instructions of when they should give a Remember, Know or Guess response in the same way as for Experiments 1 and 2.

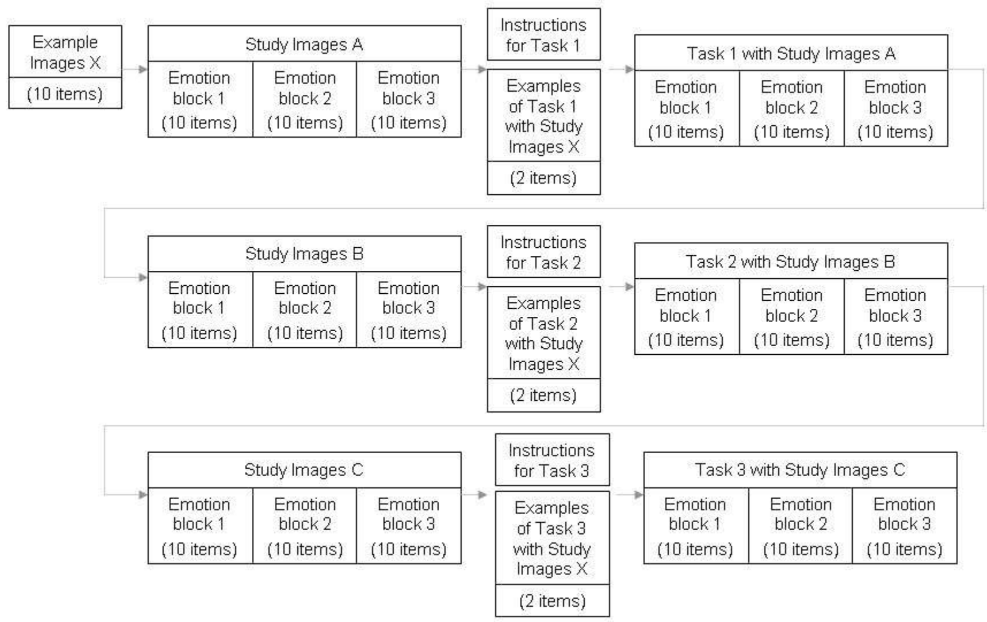


Figure 3.1. Experimental procedure

The order of the three tasks and the order of the valence blocks (positive, negative, neutral) within the task blocks was counterbalanced across participants. Two sets of stimuli were created and their use as study items or distractors at test was counterbalanced across participants. The choice of photographs presented for each task was counterbalanced across participants from three different matched selections of groups of photographs.

Section 1.3. Results

Recognition performance in all three tasks

First of all we analysed memory performance in the recognition part of each task. Overall recognition accuracy in the recognition task, recognition then confidence judgement task and recognition then RKG task was comparable with means of 0.61, 0.58 and 0.58 respectively. To ensure that performance exceeded chance (0.50 in a two-alternative forced choice test) we conducted a series of one-sample t-tests to compare performance to that expected by chance. Performance on all tasks was significantly greater than that expected by chance (Recognition: $t(35) = 7.07$, $p < .001$; Recognition then Confidence judgement: $t(35) = 5.12$, $p < .001$; Recognition then RKG judgement: $t(35) = 5.60$, $p < .001$).

The influence of emotion on recognition performance in the different tasks was compared by conducting a 3 (task) x 3 (emotion) repeated measures ANOVA on the factors task and emotion (See Figure 3.2). For all ANOVA analyses Mauchly's test of sphericity was conducted and in those cases where the assumptions were not met the Greenhouse-Geisser adjusted MSE and p values are reported, this is indicated by decimal points in the degrees of freedom. The main effect of emotion approached significance ($F_{(2,70)} = 2.98$, MSE = 7.06, $p = .06$) but the main effect of task was not significant [$F_{(2, 70)} = 2.02$, MSE=3.82, $p = 0.14$]. There was no significant interaction between task and emotion [$F_{(4, 140)} = 1.04$, MSE = 3.00, $p = .39$]. Planned contrasts comparing recognition of emotional to neutral and negative to positive stimuli were conducted to further explore the main factor of emotion. This revealed no significant difference in recognition of emotional than neutral stimuli [$F_{(1,35)} =$

0.28, $p = .60$], but did reveal significantly greater recognition of positive than negative stimuli ($F_{(1,35)} = 5.32$, $p < .05$).

Further planned contrasts were conducted to examine influence of emotion on recognition for each task. This revealed that for the task of straightforward recognition there was no significant difference between recognition of emotional and neutral items [$F_{(1,35)} = 0.22$, $p = .64$] nor between positive and negative items [$F_{(1,35)} = 1.89$, $p = .18$]. For recognition followed by a confidence judgement there was greater recognition of emotional than neutral items which was approaching statistical significance [$F_{(1,35)} = 3.84$, $p = .06$], and the greater recognition for positive than negative items was also approaching significance [$F_{(1,35)} = 3.61$, $p = .07$]. For recognition followed by RKG judgement there was no significant difference between recognition of emotional and neutral items [$F_{(1,35)} = 0.35$, $p = .56$] nor between positive and negative items [$F_{(1,35)} = 0.74$, $p = .40$].

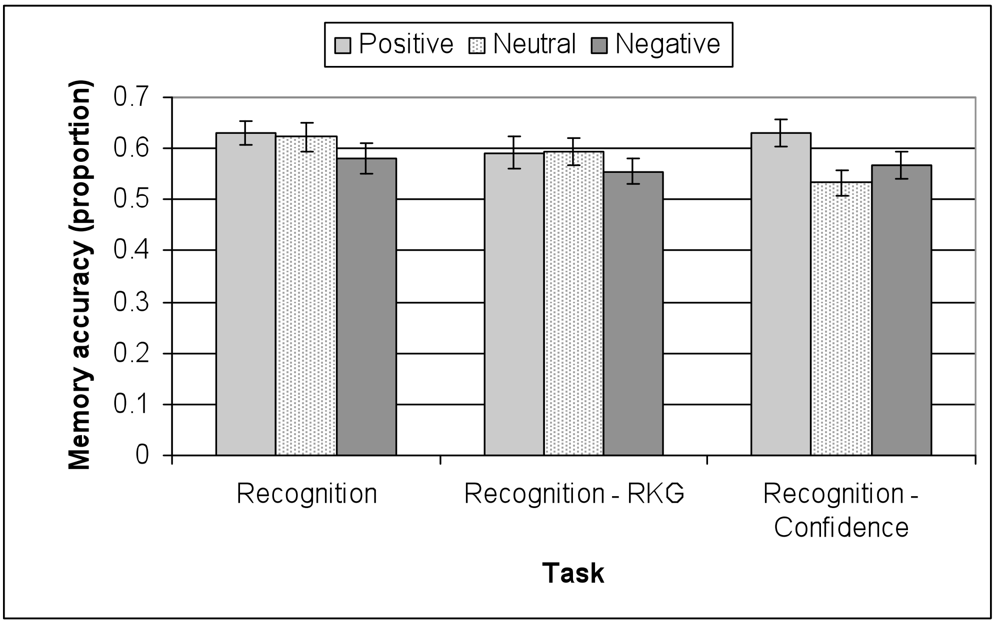


Figure 3.2. Recognition performance across task and emotion block

Analysis of RKG responses

We analysed the RKG responses to examine the influence of emotion on the responses made (See Table 3.2). We conducted separate 2 (accuracy) x 3 (emotion) ANOVAs on each of the different types of responses separately with the factor of accuracy (correct or incorrect) and emotion block (positive, negative, neutral). For the Remember responses the main effect of accuracy was significant ($F_{(1,35)} = 36.28$, MSE = 26.04, $p < .001$) with more Remember responses given after correct than incorrect recognition. The main effect of emotion block was not significant [$F_{(2,70)} = 1.61$, MSE = 0.91, $p = .21$] and nor was the interaction between emotion and accuracy [$F_{(2,70)} = 0.50$, MSE = 0.39, $p = .61$].

For the Know responses the main effect of accuracy was significant ($F_{(1,35)} = 14.71$, MSE = 22.69, $p < .01$) with more Know responses given after correct than incorrect recognition. The main effect of emotion block was not significant [$F_{(2,70)} = 1.01$, MSE = 0.78, $p = .37$] and nor was the interaction between emotion and accuracy [$F_{(2,70)} = 0.33$, MSE = 0.42, $p = .72$].

For the Guess responses the main effect of accuracy was not significant [$F_{(1,35)} = 1.53$, MSE = 3.89, $p = .22$], nor was the main effect of emotion block [$F_{(2,70)} = 1.97$, MSE = 2.53, $p = .15$], nor was the interaction between accuracy and emotion block [$F_{(2,70)} = 0.93$, MSE = 3.14, $p = .40$].

Table 3.2. Proportion of each emotion block given RKG responses by accuracy

	Remember		Know		Guess	
Emotion	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
Positive	.12	.04	.18	.11	.29	.26
Neutral	.11	.04	.15	.11	.33	.26
Negative	.08	.03	.17	.09	.31	.32

We also analysed the pattern of RKG responses given to the different emotional stimuli by conducting a 3 (response type) x 3 (emotion) ANOVA only on RKG responses given after correct recognition (see Table 3.3 for mean values). Caution is needed in the interpretation of these results due to the small number of responses on which this analysis is based as the average number of correct responses for each emotion block was approximately 5 or 6. There was a significant main effect of response type ($F_{(2,70)}$ = 28.96, MSE = 117.48, p < .001). The main effect of emotion was not significant [$F_{(2,70)}$ = 0.55, MSE = 0.57, p = .58] and nor was the interaction between emotion and response type [$F_{(4,140)}$ = 0.78, MSE = 1.35, p = .54].

Table 3.3. Average proportion of Remember, Know or Guess responses given after correct recognition of item by emotion

Emotion	Remember	Know	Guess
Positive	.20	.31	.49
Neutral	.19	.26	.55
Negative	.15	.30	.55

Further signal detection analysis of these RKG results was not possible due to the two alternative forced choice recognition used which meant that the assumptions of signal detection analysis were not met.

Analysis of Confidence judgements

We analysed the confidence judgements given after recognition to examine the influence of emotion on these responses (See Table 3.4). We conducted a 3 (emotion) x 2 (accuracy) repeated measures ANOVA with the factors emotion (positive, negative, neutral) and accuracy (correct or incorrect). The main effect of emotion block was significant ($F_{(2,70)} = 5.75$, MSE = 2.57, $p < .01$). The main effect of accuracy was significant ($F_{(1,35)} = 29.31$, MSE = 8.65, $p < .001$) with ratings of greater confidence given after correct recognition than incorrect recognition. The interaction between emotion and accuracy was also significant ($F_{(2,70)} = 3.37$, MSE = 0.88, $p < .05$). Orthogonal contrasts were conducted to further examine the main effect of emotion block and the interaction. There was no significant difference in the confidence ratings given to neutral vs. emotional items [$F_{(1,35)} = 0.79$, $p = .38$] but there was significantly higher confidence ratings given to positive than negative items ($F_{(1,35)} = 13.00$, $p < .001$). There was no significant difference in confidence ratings given after correct recognition to emotional or neutral items [$F_{(1,35)} = 0.48$, $p = .49$] but there was significantly greater confidence ratings given to positive than negative items after correct recognition ($F_{(1,35)} = 11.17$, $p < .01$). Significantly lower confidence ratings were given after incorrect recognition to emotional than neutral items ($F_{(1,35)} = 4.54$, $p < .05$) and greater confidence ratings were given to positive than negative items ($F_{(1,35)} = 6.92$, $p < .05$).

Table 3.4. Average confidence ratings (1 - Not at all confident to 5 - Very confident) by accuracy and emotion block, mean (SE)

Confidence rating of:	Positive	Neutral	Negative
Correct recognition	2.77 (0.13)	2.47 (0.17)	2.37 (0.13)
Incorrect recognition	2.21 (0.14)	2.33 (0.14)	1.88 (0.12)

Section 1.4. Discussion

We found successful recognition memory in all three tasks in this within-participant paradigm, with recognition greater than chance in all conditions. There was an overall positive emotional enhancement of recognition memory but this was not modulated by the task which participants performed at retrieval. Although planned contrasts did reveal that this emotional enhancement was driven by findings in the recognition followed by confidence task. The findings of emotional enhancement in recognition when followed by confidence judgement and lack of emotional enhancement in recognition when followed by RKG response were consistent with our predictions. However, the lack of emotional enhancement in straightforward recognition was not consistent with our predictions.

There was no influence of emotion on the Remember, Know or Guess responses given, in contrast to higher ratings of confidence given to positive stimuli, which corresponded with more successful recognition of positive stimuli in this task. These findings were consistent with our predictions.

In this experiment we found increased accuracy of recognition for positive stimuli in recognition when followed by a confidence judgement. The confidence ratings for positive stimuli were higher than for negative stimuli, regardless of accuracy of prior recognition. These findings are not consistent with earlier research (Dahl et al., 2006) which found increased accuracy and confidence for negative stimuli. The different findings in this experiment may be due to the different stimulus sets used; in particular if the erotic stimuli were used as part of the positive stimulus set in the Dahl et al. (2006) experiment this may have led to social desirability in participants and reduced their willingness to say that they were confident they had seen the erotic stimuli in that experiment and to give high confidence ratings to pictures with negative connotations. A further possibility is that the presentation of stimuli in blocked lists of emotion, compared to the mixed lists of positive and negative stimuli of Dahl et al. (2006) may have reduced any emotional enhancement (c.f. Dewhurst & Parry, 2000). It is also possible that the matching of visual characteristics between the positive, negative and neutral stimuli in this experiment may have influenced the pattern of results.

The findings of the influence of emotion on confidence judgements are interesting but are not theoretically relevant to the research questions addressed in this experiment and therefore will not be discussed further.

The aim of this experiment was to manipulate the strategy that participants used to retrieve memories by asking participants to perform different types of memory judgements. Although there were hints in the orthogonal comparisons of different emotional effects with the different tasks, the overall interaction in the ANOVA did not reach significance despite the relatively large sample size (n=36) in this experiment. It is possible that any power benefits from using the within participant design were outweighed by carryover effects across conditions. Performance in later tasks may have been contaminated by the instructions received for the recognition task recently performed and this may have lead to a mixed retrieval strategy being used rather than a single retrieval strategy for each different task block. An analysis of recognition just from the first block suggested the results in the first block may be different from the group averages which include performance over the full three blocks (see Appendix 3.2). This suggests that participants may not keep retrieval strategies separate in their mind when performing the different tasks.

The difference in memory performance as a result of retrieval strategy found in Experiments 1 and 2 was only small and the results from this experiment indicate that it may be a difficult effect to demonstrate reliably. This was a reasonably powerful within-participants study which should have had sufficient power to detect a medium effect (power of 82% to detect an effect size of d 0.5 (Clark-Carter, 1997)). The findings from this experiment do not give a clear indication of why the paradigm is not working. The hint of contamination between tasks suggests that this area of investigation may not be amenable to within-participant experimental design. The findings of Experiment 1 and 2 do have theoretical interest with regard to how factors at the time of retrieving a memory may differentially affect memory for emotional and neutral events. However, the degree to which these findings could be generalised to the real-world is not clear. It is possible that the effects of retrieval strategy may be found only when participants are exposed very briefly to stimuli whereas in most real world situations people would have much longer to process and encode information.

The main purpose of this experiment was to attempt to manipulate retrieval strategy in a within-participant design and provide an opportunity to investigate this further whilst avoiding the prohibitively large numbers of participants which would be required to demonstrate these small effects in a between-participants design. This was not successfully achieved in this experiment but these experiments did explore some of the interesting implications of using different methodologies to investigate the effects of emotion on memory. Due to the limitations in pursing this area of investigation which have been discussed above, it was decided to move to a new paradigm in Experiment 4 to investigate the influence of emotion on memory using an alternative method which has recently been used to investigate some interesting aspects of this area (e.g. Kensinger et al., 2006).

Section 2. Experiment 4: What is an effective paradigm for studying emotion's effects on memory?

Section 2.1. Introduction

In Experiment 3 the influence of emotion on the retrieval of memories was considered by comparing performance on recognition and subsequent judgements of confidence or Remember/Know/Guess. In this experiment we further investigate the influence of recognition task on emotional enhancement of memory by using a new experimental paradigm with a new set of experimental stimuli. This experiment aims to provide an alternative examination of how retrieval of memories may be affected by the task used. In this introduction there will first be a review of the contribution that research with the Remember/Know paradigm has made to the investigation of recognition memory and emotion's influence on recognition memory. Some of this material was briefly reviewed in Chapter 2 but will be considered in more detail here. Then we will consider the benefits of a different paradigm to examine recognition memory and the further insights it may reveal into the influence of emotion on recognition memory. Lastly, we will explore how performance on a Remember/Know/New task may specifically relate to performance with a paradigm which requires participants to discriminate between Same/Similar/New items.

The Remember/Know paradigm and recognition memory

The Remember/Know paradigm has been used in many experimental designs for many different purposes (for a review see Dunn, 2004). The paradigm was first introduced by Tulving (1985) to examine different states of awareness which were thought to underlie memory retrieval. In this task participants are asked to indicate the basis on which they judged a previously studied item to be ‘old’. They have to distinguish between a ‘Remember’ response to indicate they are able to remember its prior occurrence and a ‘Know’ response to indicate they simply knew it was old by some other criteria. These responses were proposed to reflect autonoetic and noetic consciousness which were thought to respectively characterise episodic and semantic memory systems (Tulving, 1985). Later work by Gardiner (1988) led to the development of operational definitions of remembering and knowing and a dissociation was reported between remember and know responses. Manipulations of levels of processing were found to affect the proportion of Remember responses but have no effect on Know responses (Gardiner, 1988). Much of the research stemming from these two first studies further investigated the extent to which Remember and Know responses can be dissociated by different experimental variables (Dunn, 2004).

The interpretation of Remember/Know responses depends on whether a single-process or dual-process model of recognition memory is assumed to be more likely (Dunn, 2004). There is a great deal of controversy in the literature over theories of recognition memory with different researchers arguing equally strongly for the single-process model and others for the dual-process model of recognition memory (for a review see Malmberg, 2008). The different interpretations of results from the paradigm will now be briefly described. Within the dual-process interpretation of the Remember/Know paradigm it is assumed that Remember and Know responses reflect different forms of memory retrieval and reflect the operation of two qualitatively different memory components, or processes. Three competing models have been identified of how Remember/Know responses relate to a dual-process model of recognition memory (Gardiner, 2001). They are as follows:

i) R responses reflect subjective experience of retrieval from episodic memory, K responses reflect subjective experience of retrieval from semantic memory (Tulving, 1985).

ii) R responses reflect the distinctiveness of processing at study, K responses reflect the fluency of processing at test (Rajaram, 1996).

iii) R responses identify with the process of recollection, K responses identify with the process of familiarity. These processes are thought to underlie recognition memory (Jacob, Yonelinas, & Jennings, 1997).

Researchers identifying Remember/Know responses within a single-process model of recognition memory have argued that the different responses reflect different levels of confidence in the items produced as a result of memory retrieval (e.g. Donaldson, 1996). According to this model participants are purported to interpret instructions for the Remember/Know paradigm as indicating that more stringent criteria is required for a remember than know response, and if there is not enough trace strength of a test item for a know response then a new (or guess) response would be made. This interpretation is called the signal-detection theory of the Remember/Know paradigm (Dunn, 2004).

The nature of recognition memory and the suitability of different theoretical frameworks remains a hotly debated topic in the literature (e.g. Knott & Dewhurst, 2007; Malmberg, 2008; Rotello & Macmillan, 2006; Wixted, 2007). In this experiment, however, we will be using the Remember/Know paradigm in the context of research to investigate emotions' influence on memory and therefore will not be making any conclusions with regard to support for different models of recognition memory. This is consistent with other research in the area of emotion and memory which has reported the proportion of responses given without reference to any particular theoretical interpretation of the results according to single or dual process models of recognition memory (e.g. Dolcos, LaBar, & Cabeza, 2005).

The Remember/Know paradigm and emotions' influence on memory

There has been a great deal of research that has used the Remember/Know paradigm to investigate the influence of emotion on memory. As described in Chapter 2, advantages in memory have been found for both positive and negative stimuli (Dewhurst & Parry, 2000; Dolcos et al., 2005; Mickley & Kensinger, 2008; Ochsner, 2000). In some studies the advantage has been found for positive and negative photographs in both Remember and Know responses (Mickley & Kensinger, 2008), whereas in other studies the emotional advantage has only been apparent in Remember responses (Dewhurst & Parry, 2000; Dolcos et al., 2005; Ochsner, 2000).

The Same/Similar/New paradigm and recognition memory

There has recently been a body of work published which examined the effect of emotion on memory using a new paradigm which identifies participants' abilities to identify specific visual details of experimental stimuli

(Kensinger et al., 2006; Kensinger, Garoff-Eaton, & Schacter, 2007a, 2007b). In this paradigm participants were shown pictures of objects during the study phase; each object in the study phase had a corresponding picture in the test phase which was either the *same* or *similar* and in addition *new* pictures were shown as distractors. For example, a participant who saw a picture of a spider in the study phase would in the test phase see the *same* picture of a spider or a *similar* picture of a spider. For each object in the test phase participants would have to indicate whether it was the *same*, *similar* or *new*. General recognition was calculated as the number of times an object seen at encoding was remembered either with or without specific details ('same' and 'similar' responses). Specific recognition was measured as the number of 'same' responses, that is, the number of times an object was correctly remembered with specific detail.

The Same/Similar/New paradigm and emotions' influence on memory

For objects presented in isolation there was an enhancement in specific memory for negative over neutral pictures but there was no difference in general recognition between negative and neutral pictures (Kensinger et al., 2006). This effect was modulated by the length of time participants were exposed to the stimuli. At brief encoding durations of 500ms the negative emotional enhancement was only apparent with specific recognition (Kensinger et al., 2006), whereas at longer encoding durations of one, two and five seconds both specific and general recognition was enhanced (Kensinger et al., 2006, 2007a, 2007b).

The relation between Remember/Know/New (RKN) & Same/Similar/New(SSN)

The purpose of using the SSN paradigm is to assess the level of detail in participant's memory, whereas the purpose of using the RKN paradigm is to assess the level of subjective awareness in the participant's memory. Even though the two paradigms have different criteria for giving a particular response they have a similar structure of a three level discrimination task which warrants a comparison between the two methodologies. This may provide further insight into the way in which participants interpret the task instructions in each case. A theoretical relationship between SSN and RKN responses was proposed by examining the criteria by which participants should respond if they are following the instructions for the tasks (See Table 3.5). This relationship was considered only for items that would be the *same* at study and test as these would be targets for some form of recognition in both tasks. In contrast a *similar* item would be given a response indicating some form of recognition in the SSN task, whereas the appropriate response in the RKN task should indicate no recognition memory because the item has not been seen before. N*ew* items would form the entire set of distractors for the SSN task but only a subset of distractors for the RKN task.

Table 3.5. Criteria for giving responses to *same* items in the Same, Similar, New task and Remember, Know, New task

Same, Similar, New task	Remember, Know, New task
Same: Exact item seen before, recognition of specific visual details	Remember: Recognition accompanied by some recollective experience of encoding context
Similar: Recognise that an item similar to this, but not this exact photograph, was seen before OR Recognise item but cannot remember specific visual details so cannot give a 'same' response	Know: Recognition accompanied by strong feelings of familiarity in absence of any recollective experience
New: Do not recognise item	New: Do not recognise item

The criteria for giving a Same, Similar or New response should be based on an objective criterion of firstly whether there is any recognition of the item, and if there is whether there is recognition of specific visual details (same response) or not (similar response). The criteria for giving a Remember, Know or New response should also firstly be based on an objective criterion of whether there is any recognition of the items, and then considering whether any feelings of recollective experience accompany the recognition (Remember response) or not (Know response). Based on the criteria for giving these responses we proposed a relationship to describe how SSN and RKN responses may be related to each other (see Figure 3.3).

We proposed that a Remember response would only be given in instances when there was true recognition of the exact item which would include the specific visual details, but that not all instances of true recognition would be accompanied by some recollective experience of the encoding context. We proposed that a Know response would be given in instances of recognition of the item when the memory did include memory for the specific visual details but there was no accompanying recollective experience and also when there was no memory for the specific visual details but some recognition of the item. We proposed that a New response in the RKN task would be given in instances where there was no recognition at all of the item (when a new response would be given in the SSN task) and also in some of the instances where a similar response would be given in the SSN task when these indicate that there is no recognition of this particular item but there is semantic activation indicating that an item similar to this was seen before. We are making no predictions of the relative proportions for each response and therefore roughly one third of each response type is indicated.

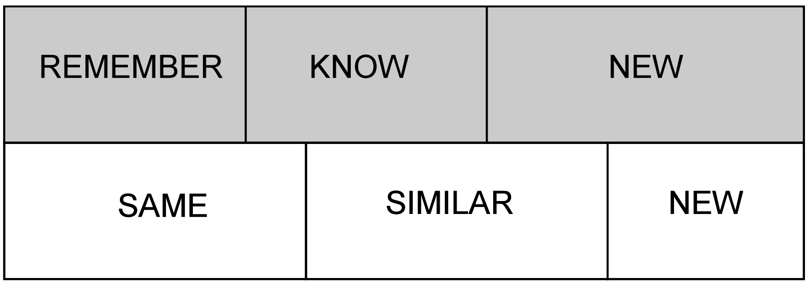


Figure 3.3. Possible relationship between Same, Similar, New and Remember, Know, New responses to *Same* items

We predict that emotion would affect the pattern of responses given in the RKN and SSN task in the same direction. Therefore, we predict for negative items there will be a greater proportion of Remember than Know or New responses and a greater proportion of Same than Similar or New responses. We predict a greater proportion of Remember responses in the RKN task, and Same responses in the SSN task, will be given to negative than neutral items (cf. Kensinger et al, 2006). The degree to which the different categories of response are affected by emotion could provide some insight into any different memory processes being measured by these two tasks.

Section 2.2. Method

Design

In this experiment we used a 2 x 2 mixed design with the within participants factor of emotion (negative, neutral) and the between participants factor of memory task (RKN, SSN). Participants were shown negative and neutral stimuli in a within-participant mixed-list design and were in either of the memory measurement groups.

Participants

Forty-eight participants (26 female) took part in this experiment. All were native English-speaking University of Nottingham students (mean age = 20.88 years, SD = 2.14). Informed consent was obtained from all participants. Participants received an inconvenience allowance of £6 for their voluntary participation. The School of Psychology, University of Nottingham Ethics Committee gave approval for the study. Participants were randomly allocated to either the RKN or SSN memory task and took part in only one of these tasks.

Materials

Stimuli ratings

We wanted to be sure that the stimuli in our experiment were comparable to those used by Kensinger et al. (2006) as it was critical to the conclusions we could make in this experiment. Unfortunately, we were unable to use the exact list of stimuli that was used by Kensinger et al., but in order to make our stimulus set as close as possible to that of Kensinger we have used the same ratings methodology reported by Kensinger et al (2006) and have tried to match our stimuli to their ratings where possible.

To produce the set of stimuli that were used in this experiment an initial group of 405 pairs of photographs of objects were selected by the researcher with the aim that one third of these stimuli were each of negative, neutral and positive emotion. The positive stimuli were not used in this experiment but were included for some of the ratings so they could be used in Experiment 5 (reported later in this thesis). For this experiment the ratings of emotion were conducted on a set of stimuli containing only the 270 pairs of potential negative and neutral stimuli, not the positive stimuli. This was to ensure that the ratings of emotion were given in a similar context to that in which they would be experienced by participants of the experiment. All other ratings (perceptual features and familiarity) were conducted on the entire set of 405 pairs of photographs. The average ratings given below are for those stimuli that were included in the final set of experimental stimuli.

Emotion ratings.

There were 540 photographs of objects (270 pairs) rated individually for valence and arousal on an 11-point scale, from -5 (*negative)* to +5 (*positive*) and -5 (*calming / soothing*) to +5 (*exciting / agitating*) respectively. Participants were told to base their ratings on their initial reaction to the objects in the photographs. Twenty University of Nottingham students conducted the ratings (13 female; Mean age: 19.55 years, SD 1.61). The negative and neutral groups of stimuli were given distinct mean average item ratings (with range and standard deviation in parentheses) for valence of -1.89 (-3.90 to -0.40; 0.82) and 0.79 (-0.35 to 2.55; 0.61) and for arousal of 2.20 (-0.5 to 3.70; 0.82), and -0.76 (-2.65 to 1.25; 0.70) respectively.

Perceptual features:

i) Similarity.

There were 405 pairs of photographs of objects rated for similarity between the items in a pair by 10 University of Nottingham students (7 female; Mean age: 26.80 years, SD 3.46 years). Each pair was rated on a scale of 1 (*items incredibly similar*) to 10 (*items incredibly different*). The average ratings of similarity between items were comparable between the negative and neutral and object pairs with item means (with standard deviation in parentheses) of 3.39 (1.37) and 4.04 (1.28) respectively.

ii) Dimensions of change.

There were 405 pairs of photographs of objects rated for the dimensions that could differ between the two items in the pair (colour, shape, size, orientation) by two University of Nottingham students (2 female; Mean age: 27.50 years). A rating of 0 indicated that no change in a particular dimension occurred (e.g., if both pumpkins were orange); a rating of 0.5 indicated a slight change in a dimension (e.g., a light green pine tree versus a dark green pine tree) and a rating of 1 indicated a substantial change (e.g., a red apple versus a green apple). Average ratings of how these dimensions changed between the items in a pair were comparable between the different emotional groups. The item means (with standard deviations in parentheses) for negative and neutral object pairs were: for colour .45 (.34), and .70 (.32); for orientation .62 (.35) and .61 (.35); for shape .44 (.29) and .41 (.26); and for size .22 (.24) and .17 (.22) respectively.

iii) Size.

There were 405 photographs of objects (1 item from each pair) rated for size by one University of Nottingham student (Female, 20 years). Forty-five percent of all the experimental stimuli were judged to fit into a shoebox in real life. This was similar across groups of negative (34 items) and neutral (48 items) stimuli.

Familiarity

i) Word frequency and word familiarity.

Word frequency and word familiarity (Wilson, 1988) for the 270 verbal labels of the object pairs were comparable between the negative and neutral groups of stimuli. The average ratings (standard deviations in parentheses) for negative and neutral stimuli were for written word frequency 59.30 (102.65) and 57.02 (195.38) and for word familiarity 388.15 (245.43) and 417.05 (236.10) respectively.

ii) Familiarity of object.

There were 405 photographs of objects (1 item from each pair) rated for familiarity on a scale of 1 (*highly unfamiliar*) to 10 (*highly familiar*) by one

University of Nottingham student. Mean average item ratings (with standard deviations in parentheses) were comparable for negative and neutral objects and were 4.51 (2.46) and 4.13 (3.81) respectively.

Procedure

Study.

Participants were presented with 152 nameable, colour photographs of objects (76 negative, 76 neutral). Items were presented for 500 ms with a variable inter-stimulus interval of between 6 and 14 seconds, which was randomly determined for each item. Participants were presented with a photograph, then had to make a task decision during the inter-stimulus interval whilst a central fixation cross was displayed. In this task participants had to indicate by key press (1 = Yes, 0 = No) whether in the real world the object would fit inside a shoebox. A real shoebox was placed next to participants throughout the experiment for reference. This was the task used by Kensinger et al. (2006) and ensured that, with the short presentation times of stimuli, participants did encode and process each object. The order of items was pseudorandomised so that no more than four items of one emotion were presented sequentially.

Test.

After an interval of at least two days participants completed a surprise recognition test. Participants allocated to the SSN task were presented with three types of stimuli: *same,* photographs of objects that were exactly the same as those at study; *similar,* objects shared same verbal label but were not identical to those at study; and *new,* objects that had not previously been presented. Each object was presented centrally on the screen and participants were prompted to indicate by key press whether the item was *same*, *similar* or *new*. Participants were then asked to indicate their level of confidence in this decision (low or high) by pressing correspondingly labelled keyboard keys. Items were presented in a randomised order. Following Kensinger et al (2006) a total of 76 items were shown that were the *same* at study and test, 76 items were shown that were *similar* to those shown at study (i.e. the other item from the object pair) and 38 items were shown that were new. Half of each of the *same*, *similar* and *new* items were negative or neutral. All participants were presented with exactly the same photographs at test, whether these items were the *same*, *similar* or *new* for each participant was counterbalanced by varying the item of the object pair and the stimuli lists which were shown at study.

Participants allocated to the RKN task were firstly given printed instructions detailing how to complete the task. These were taken from Gardiner & Richardson-Klavehn (2005) with an alteration of the first and last paragraph where YES and NO were exchanged for 'Remember' or 'Know' and 'New' respectively. The instructions were as follows (italics added here):

In this test you will see a series of pictures, one picture at a time. Some of the pictures are those that you saw in the earlier experimental session. Others are not. For each picture, please indicate if you recognise the picture as one you saw in the earlier experimental session by pressing 'Remember' or 'Know'. If you do not think the picture was one you saw earlier please press 'New'.

Recognition memory is associated with two different kinds of awareness. Quite often recognition brings back to mind something you recollect about what it is *that you recognise, as when, for example, you recognise someone's face, and perhaps* <u>*remember*</u> *talking to this person at a party the previous night.*

At other times recognition brings nothing back to mind about what it is you recognise, as when, for example, you are confident that you recognise someone, and you <u>*know*</u> *you recognise them, because of strong feelings of familiarity, but you have no recollection of seeing this person before. You don* (sic) *not remember anything about them.*

The same kinds of awareness are associated with recognizing the pictures you saw in the earlier experimental session. Sometimes when you recognise a picture as one you saw earlier, recognition will bring back to mind something you remember thinking about when the picture appeared then. You recollect something you consciously experienced at that time. But sometimes recognizing a picture as one you saw earlier, will not bring back to mind anything you remember about seeing it then. Instead, the picture will seem familiar, so that you feel confident it was one you saw earlier, even though you don't recollect anything you experienced when you saw it then.

For each picture please press the 'REMEMBER' button, if recognition is accompanied by some recollective experience, or the 'KNOW' button, if recognition is accompanied by strong feelings of familiarity in the absence of any recollective experience.

When you think the picture was not one you saw earlier, press the 'NEW' button.

If you have any questions please ask the experimenter.

Participants were presented with photographs of *same*, *similar* and *new* items as were participants in the SSN task except participants had to give a 'remember', 'know' or 'new' response to indicate their level of awareness of their memory for the object presented, rather than giving a 'same', 'similar' or 'new' response. All other aspects of the procedure were exactly the same in both tasks.

To enable counterbalancing the items were presented across four lists with 38 items in each list (19 negative, 19 neutral). A fifth list of items was shown only at test. At the time of debriefing 38 participants confirmed they were not expecting to have their memory tested. Three participants reported they were expecting a memory test and seven participants were not sure. Overall memory performance was comparable between these three groups therefore this distinction is not considered further.

Section 2.3. Results

Task A: Same, Similar, New

Memory performance on the SSN task was examined by separately examining the responses given when participants were presented with the 3 different type of items (items that were same, similar or new at test) (see Table 3.6). Firstly, a 2 x 3 repeated measures ANOVA with the factors emotion (negative, neutral) and response type (‘same’, ‘similar’, ‘new’) was conducted on the *same* items. There was a significant main effect of response type ($F_{(1.49,34.18)}$ = 10.85, MSE = 1.01, p < .001, partial eta^2 = .32) and a significant interaction between emotion*response type ($F_{(2,46)}$ = 6.25, MSE = 0.07, p < .01, partial eta^2 = .21). Post-hoc t-tests were carried out to compare the proportion of each response type by emotion. Significantly more negative than neutral items were given a ‘same’ response (t (23) = 3.57, p < .01) and less negative than neutral items were given a ‘new’ response (t (23) = -2.26, p < .05). There was no significant difference in the proportion of negative and neutral items given a ‘similar’ response [t (23) = -1.22, p = .24]. Orthogonal contrasts were conducted to further examine the main effect of response type. There were significantly more ‘same’ than ‘similar’ or ‘new’ responses given ($F_{(1,23)}$ = 9.88, p < .01) and significantly more ‘similar’ than ‘new’ responses given ($F_{(1,23)}$ = 14.57, p < .001).

A repeated measures ANOVA with the factors emotion (negative, neutral) and response type (‘same’, ‘similar’, ‘new’) was then conducted on the *similar* items. There was a significant main effect of response type ($F_{(1.48,34.03)}$ = 16.69, MSE = 1.23, p < .001, partial eta^2 = .42) and a significant interaction between emotion*response type ($F_{(2,46)}$ = 6.27, MSE = 0.08, p < .01, partial eta^2 = .21). Post-hoc t-tests were carried out to compare the proportion of each response type by emotion. There were significantly more same responses given to negative than neutral items (t (23) = 3.28, p < .01) and significantly less new responses to negative than neutral items (t (23) = -3.22, p < .01). There was no significant difference between the proportion of similar responses given to negative than neutral items [t (23) = 0.73, p =.47]. Orthogonal contrasts were conducted to further analyse the main effect of response type. There were significantly more 'similar' than 'same' or 'new' responses given ($F_{(1,23)}$ = 9.82, $p < .01$) and significantly more 'new' than 'same' responses ($F_{(1,23)}$ = 29.87, $p < .001$).

A repeated measures ANOVA with the factors emotion (negative, neutral) and response type ('same', 'similar', 'new') was then conducted with the *new* items. There was a significant main effect of response type ($F_{(1.44,33.23)}$ = 282.93, MSE = 7.48, $p < .001$, partial eta^2 = .93) but no significant interaction between emotion and response type [$F_{(1.38,31.83)}$ = 1.51, MSE = 0.02, $p = .23$, partial eta^2 = .06]. Orthogonal contrasts were conducted to further analyse the main effect of response type and revealed significantly more 'new' than 'same' or 'similar' responses were given ($F_{(1,23)}$ = 349.83, $p < .001$) and significantly more 'similar' than 'same' responses were given ($F_{(1,23)}$ = 35.70, $p < .001$).

Visual specificity was measured by Kensinger et al. (2006) by calculating specific recognition as the 'same' responses to the *same* items, and general recognition as the 'same' and 'similar' responses to the *same* items. Specific recognition (mean, S.E.) was significantly greater for negative (.50, SE .04) than neutral (.41, SE .04) items (t (23) = 3.57, $p < .01$). General recognition was also significantly greater for negative (.85, SE .03) than neutral (.76, SE .03) items (t (23) = 2.26, $p < .05$).

Table 3.6. Mean average proportion (SE) of Same, Similar, New items given Same/Similar/New responses for Negative and Neutral items

Response type:	Same items	Similar items	New items
		Negative objects	
'Same'	.50 (.04)	.18 (.02)	.05 (.02)
'Similar'	.32 (.03)	.46 (.03)	.18 (.02)
'New'	.18 (.03)	.36 (.04)	.76 (.03)
		Neutral objects	
'Same'	.41 (.04)	.12 (.02)	.04 (.01)
'Similar'	.35 (.03)	.44 (.05)	.12 (.02)
'New'	.23 (.03)	.45 (.04)	.80 (.03)

Confidence Ratings

The influence of emotion on the confidence ratings (low, high) and response type given to *same, similar* and *new* items was analysed by conducting a 2 (confidence) x 3 (response type) x 2 (emotion) repeated measures ANOVA (for brevity the ANOVA results are reported in Tables 3.7, 3.8 and 3.9). The emotional content of *similar* and *new* items did not affect the distribution of confidence ratings as reflected by the lack of a significant three-way interaction between confidence, response type and emotion. However, this interaction was significant with *same* items, although the associated effect size for this interaction was very small. The influence of confidence was checked further by analyzing the pattern of results when only high confidence responses were included in the analysis. For all types of items the same main effects and interactions in the ANOVAs were found as when analysis was collapsed across confidence ratings. Therefore, we follow Kensinger et al (2006) in concluding that the level of confidence does not have a major influence on the emotional enhancement of visual specificity of memory and we will not discuss confidence ratings further.

Table 3.7. Same/Similar/New task: Same items. Repeated measures ANOVA to examine influence of emotion on confidence ratings

Effect	**$F_{(df)}$**	**MSE**	***p***	**Partial Eta^2**
Confidence (low,high) x Response type (‘same’, ‘similar’, ‘new’) x Emotion (negative, neutral)				
Confidence	$66.59_{(1,23)}$	1.73	< .001	.74
Response type	$10.85_{(1.49,34.18)}$	0.38	< .001	.32
Confidence*Response type	$23.57_{(2,46)}$	0.63	< .001	.51
Confidence*Emotion	$3.73_{(1,23)}$	0.03	.07	.14
Response type*Emotion	$6.25_{(2,46)}$	0.03	< .01	.21
Confidence*Response type* Emotion	$5.07_{(2,46)}$	0.03	< .01	.18
High Confidence ratings only: Response type (‘same’, ‘similar’, ‘new’) x Emotion (negative, neutral)				
Response type	$18.13_{(2,46)}$	0.98	< .001	.44
Emotion	$3.733_{(1,23)}$	0.01	.07	.14
Response type* Emotion	$6.67_{(2,46)}$	0.06	< .01	.23

Table 3.8. Same/Similar/New task: Similar items. Repeated measures ANOVA to examine influence of emotion on confidence ratings

Effect	**$F_{(df)}$**	**MSE**	***p***	**Partial Eta^2**
Confidence (low,high) x Response type ('same', 'similar', 'new') x Emotion (negative, neutral)				
Confidence	$32.98_{(1,23)}$	0.96	< .001	.59
Response type	$16.69_{(1.48,34.03)}$	0.62	< .001	.42
Confidence*Response type	$1.74_{(1.60,36.87)}$	0.06	.19	.07
Confidence*Emotion	$6.65_{(1,23)}$	0.05	< .05	.22
Response type*Emotion	$6.27_{(2,46)}$	0.04	< .01	.21
Confidence*Response type* Emotion	$0.26_{(2,46)}$	0.001	.78	.01
High Confidence ratings only: Response type ('same', 'similar', 'new') x Emotion (negative, neutral)				
Response type	$7.56_{(1.52,34.97)}$	0.46	< .001	.25
Emotion	$6.65_{(1,23)}$	0.02	.02	.22
Response type* Emotion	$3.92_{(2,46)}$	0.03	< .05	.15

Table 3.9. Same/Similar/New task: New items. Repeated measures ANOVA to examine influence of emotion on confidence ratings

Effect	**$F_{(df)}$**	**MSE**	***p***	**Partial Eta^2**
Confidence (low,high) x Response type ('same', 'similar', 'new') x Emotion (negative, neutral)				
Confidence	$21.47_{(1,23)}$	1.07	< .001	.48
Response type	$282.93_{(1.45,33.23)}$	5.18	< .001	.93
Confidence*Response type	$22.51_{(1.06,24.46)}$	1.81	< .001	.50
Confidence*Emotion	$1.97_{(1,23)}$	0.01	.17	.08
Response type*Emotion	$1.51_{(1.38,31.83)}$	0.01	.23	.06
Confidence*Response type* Emotion	$0.67_{(1.42,32.63)}$	0.01	.47	.03
High Confidence ratings only: Response type ('same', 'similar', 'new') x Emotion (negative, neutral)				
Response type	$110.42_{(1.13,25.99)}$	7.44	< .001	.83
Emotion	$1.97_{(1,23)}$	0.01	.17	.08
Response type* Emotion	$0.71_{(1.49,34.21)}$	0.01	.46	.03

Task B: Remember, Know, New

Memory performance on the RKN task was examined by separately analysing responses given to items that were the *same* at test (targets) and items that were *similar* or *new* at test (distractors) (see data in Table 3.10). A repeated measures ANOVA with the factors emotion (negative, neutral) and response type (remember, know, new) was conducted with the *same* items.

There was a significant main effect of response type ($F_{(1.41,32.38)}$ = 30.30, MSE = 2.28, p < .001, partial eta^2 = .57) and a significant interaction between emotion and response type ($F_{(2,46)}$ = 8.06, MSE = 0.10, p < .001, partial eta^2 = .26). This interaction was analysed further with post-hoc t-tests to compare the responses given to negative and neutral items. Significantly more remember responses were given to negative than neutral items (t (23) = 3.87, p < .001). There was no significant difference in the know responses given to negative and neutral items [t (23) = -1.68, p < .11]. Significantly less new responses were given to negative than neutral items (t (23) = -2.50, p < .02). Orthogonal contrasts revealed significantly more 'remember' than 'know' or 'new' responses were given ($F_{(1,23)}$=36.04, p < .001), although there was no significant difference between the number of 'know' or 'new' responses given [$F_{(1,23)}$=3.42, p = .08].

Next, a repeated measures ANOVA with the factors emotion (negative, neutral) and response type (remember, know, new) was conducted with the distractors, that is the items that were *similar* or *new* at test. There was a significant main effect of response type ($F_{(1.40,32.18)}$ = 72.61, MSE = 4.23, p < .001, partial eta^2 = .76) and a significant interaction between emotion and response type ($F_{(1.61,36.99)}$ = 21.37, MSE = 0.11, p < .001, partial eta^2 = .48). This interaction was analysed further with post-hoc t-tests to compare the responses given to negative and neutral items. Significantly more remember responses were given to negative than neutral items (t (23) = 7.15, p < .001) and significantly less new responses were given to negative than neutral items (t (23) = -5.52, p < .001). There was no significant difference in the know responses given to negative and neutral items [t (23) = 0.89, p = .38].

Orthogonal contrasts revealed that significantly more 'new' than 'remember' or 'know' responses were given ($F_{(1,23)}$=87.75, p < .001) and there was no significant difference in whether 'remember' or 'know' responses were given [$F_{(1,23)}$=0.04, p = 0.84].

Table 3.10. Mean average proportion (SE) of Targets (same items) and Distractors (similar + new items) given Remember/Know/New responses for Negative and Neutral items

Response type:	Targets (Same items)	Distractors (Similar + New items)	Similar items	New items
		Negative objects		
Remember	.63 (.04)	.23 (.02)	.35 (.03)	.10 (.02)
Know	.22 (.03)	.20 (.02)	.25 (.02)	.14 (.02)
New	.15 (.03)	.57 (.03)	.39 (.03)	.76 (.04)
		Neutral objects		
Remember	.53 (.05)	.15 (.02)	.24 (.03)	.05 (.01)
Know	.26 (.03)	.18 (.02)	.23 (.02)	.14 (.03)
New	.21 (.03)	.67 (.03)	.53 (.04)	.81 (.03)

Confidence ratings

The influence of emotion on the confidence ratings and response type given to target (*same*) and distractor (*similar* and *new*) items was analysed by conducting a 2 (confidence) x 3 (response type; Remember, Know, New) x 2 (emotion) repeated measures ANOVA (see Tables 3.11 and 3.12). The emotional content of *same* items did affect the distribution of confidence ratings as reflected by the significant three-way interaction between confidence, response type and emotion. This interaction was, however, not significant with the distractor items. The influence of confidence was checked further by analyzing the pattern of results when only high confidence responses were included in the analysis. For targets and distractors the same main effects and interactions in the ANOVAs were found as when analysis was collapsed across confidence ratings. The influence of emotion on confidence ratings in a RKN task appears to be greater than the influence it has in a SSN task as evidenced by the greater effect size in the three-way interaction for the former task. This may prove to an interesting area for investigation however, the main focus of this experiment is to compare the efficacy of either task in examining the influence of memory on emotion and therefore will not be examined further here.

Table 3.11. Remember/Know/New task: Same items. Repeated measures ANOVA to examine influence of emotion on confidence ratings

Effect	**$F_{(df)}$**	**MSE**	***p***	**Partial Eta^2**
Confidence (low,high) x Response type ('remember', 'know', 'new') x Emotion (negative, neutral)				
Confidence	$128.43_{(1,23)}$	2.45	< .001	.85
Response type	$30.30_{(1.41,32.38)}$	1.62	< .001	.57
Confidence*Response type	$32.70_{(1.52,35.00)}$	1.69	< .001	.59
Confidence*Emotion	$11.88_{(1,23)}$	0.04	< .01	.34
Response type*Emotion	$8.06_{(2,46)}$	0.05	< .001	.26
Confidence*Response type* Emotion	$7.38_{(2,46)}$	0.04	< .01	.24
High Confidence ratings only: Response type ('remember', 'know', 'new') x Emotion (negative, neutral)				
Response type	$34.62_{(1.35,31.05)}$	3.57	< .001	.60
Emotion	$11.88_{(1,23)}$	0.02	< .01	.34
Response type* Emotion	$10.29_{(2,46)}$	0.09	< .001	.31

Table 3.12. Remember/Know/New task: Distractors (Similar and New items). Repeated measures ANOVA to examine influence of emotion on confidence ratings

Effect	**$F_{(df)}$**	**MSE**	***p***	**Partial Eta^2**
Confidence (low,high) x Response type ('remember', 'know', 'new') x Emotion (negative, neutral)				
Confidence	$21.59_{(1,23)}$	1.00	< .001	.48
Response type	$72.61_{(1.40,32.18)}$	2.12	< .001	.76
Confidence*Response type	$11.79_{(1.22,28.01)}$	0.57	< .001	.34
Confidence*Emotion	$3.18_{(1,23)}$	0.01	.09	.12
Response type*Emotion	$21.37_{(1.61,36.99)}$	0.05	< .001	.48
Confidence*Response type* Emotion	$0.26_{(2,46)}$	0.001	.78	.01
High Confidence ratings only: Response type ('remember', 'know', 'new') x Emotion (negative, neutral)				
Response type	$42.63_{(2,46)}$	2.63	< .001	.65
Emotion	$3.18_{(1,23)}$	0.01	.09	.12
Response type* Emotion	$9.08_{(2,46)}$	0.03	< .001	.28

Comparison of memory performance as measured by Same, Similar, New or Remember, Know, New task

The measurement of memory performance by the SSN or RKN task was compared by examining responses given to *same* items at study and test. It was not meaningful to compare responses to *similar* or *new* items because suitable responses were not equable in the SSN task where a specific response of ‘similar’ or ‘new’ would be correct whereas for the RKN task these items would both be distractors and should be given a ‘new’ response. Analysis was conducted only on Remember/Know and Same/Similar responses because as the total number of responses in each task was the same and the main effect of task would be meaningless if all RKN and SSN responses were included. In this analysis, a main effect of task will imply a difference in the number of ‘New’ responses given. A 2 (task) x 2 (response type: same/remember, similar/know) x 2 (emotion) was conducted with the between participants factor of task and the repeated measures factors of response type and emotion. The main effect of response type was significant ($F_{(1,46)} = 26.66$, MSE = 2.54, $p < .001$, partial eta^2 = .37). The interaction between response type and task was significant ($F_{(1,46)} = 6.35$, MSE = 0.60, $p < .05$, partial eta^2 = .12), as was the interaction between response type and emotion ($F_{(1,46)} = 16.37$, MSE = 0.22, $p < .001$, partial eta^2 = .26). There was a significant main effect of emotion ($F_{(1,46)} = 11.22$, MSE = 0.04, $p < .05$, partial eta^2 = .20). The interaction between emotion and task was not significant [$F_{(1,46)} = 0.01$, MSE = < 0.01, $p = .91$, partial eta^2 < .01] and neither was the interaction between response type*emotion*task [$F_{(1,46)} = 0.31$, MSE < 0.01, $p = .58$, partial eta^2 = .01]. The main effect of task was not significant [$F_{(1,46)} = 0.56$, MSE = 0.01, $p = .46$, partial eta^2 = .01]. (See Figure 3.4).

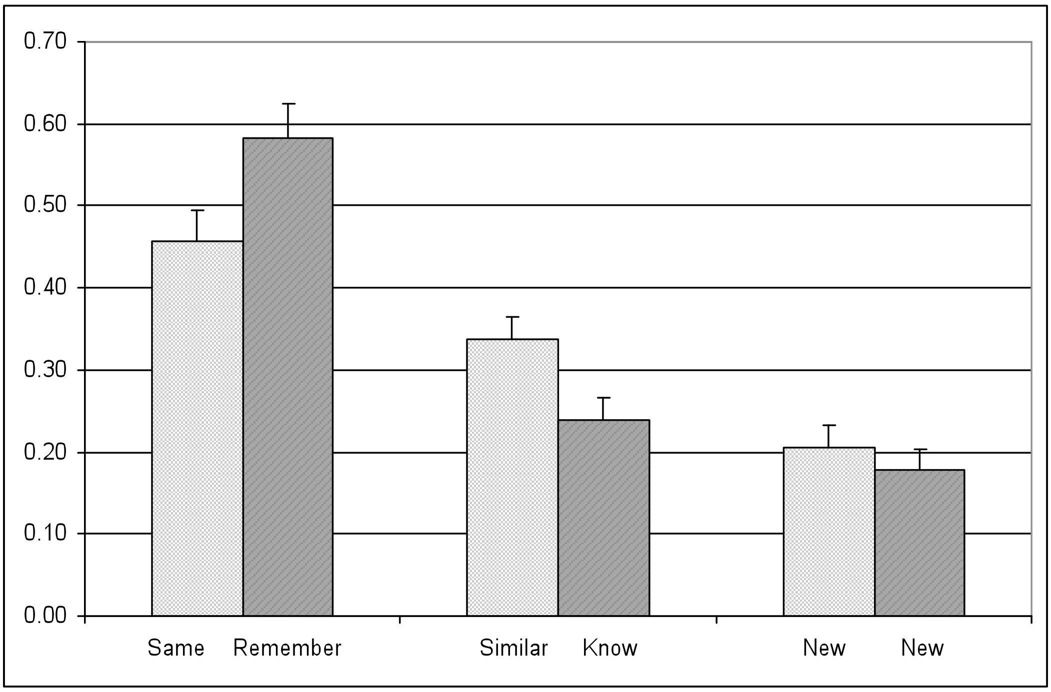


Figure 3.4. Responses to *Same* items in the Same/Similar/New and Remember/ Know/New task

Section 2.4. Discussion

Using a SSN task we found emotional enhancement of visual specificity of memory with greater specific and general recognition for negative stimuli. Using a RKN task we found greater levels of recollective experience with negative than neutral stimuli. The same pattern of results was found with both memory tasks but the results did suggest that different criteria may be used to decide which level of response should be given. There was no interaction with emotion between the two tasks suggesting that the SSN task is uncovering the same pattern of emotional influence on memory as the RKN task. The visual specificity of memory with greater specific and general recognition for negative stimuli is consistent with the findings of Kensinger et al. (2006).

We found that more ‘remember’ responses were given to negative than neutral photographs, but there was no difference in the number of ‘know’ responses given. These findings are consistent with those of Ochsner (2000), Dewhurst & Parry (2000) and Dolcos et al. (2005) who found the same pattern of results. However, they are not consistent with Mickley and Kensinger (2008) who also found emotional enhancement of ‘know’ responses.

The relationship between SSN responses and RKN responses was not as predicted. In contrast to the prediction that all Remember responses would overlap with Same responses, a greater proportion of Remember responses than Same responses given, suggesting that some recollection is based on recognition of items without memory for the specific visual detail of that item (See Figure 3.5 which indicates the average proportion of responses found in the two paradigms. The length of each bar in the figure represents the average proportion of that response to *same* items).

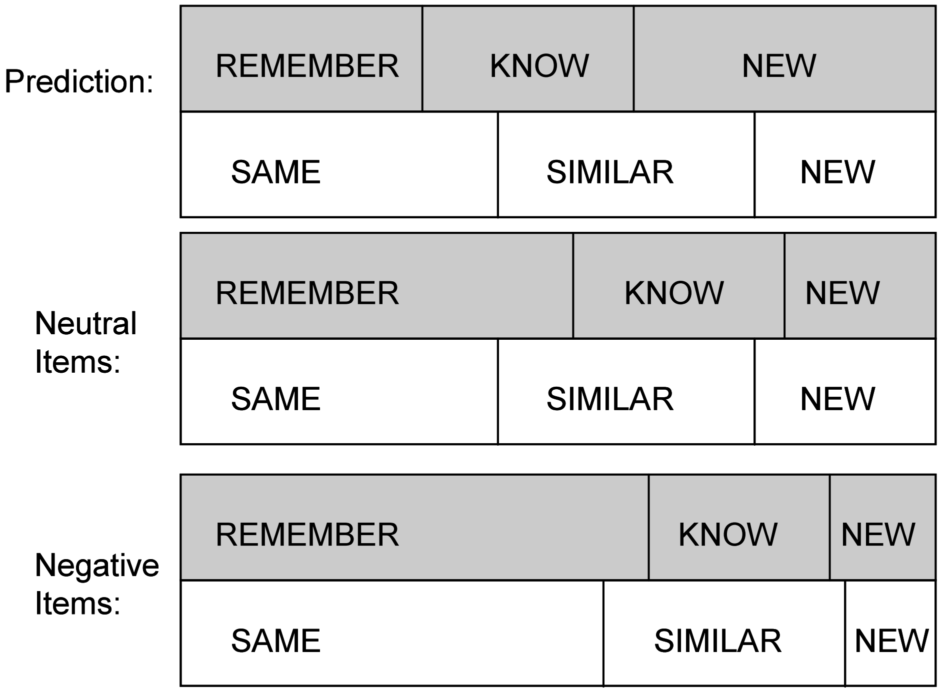


Figure 3.5: Relationship between Same/Similar/New and Remember/Know/New responses to *Same* items

The SSN and RKN tasks appear to be sensitive to emotional manipulations in the same way. However, the Remember responses are difficult to interpret because they imply that participants may use a Remember response even though they cannot remember the specific visual details. This was contrary to our expectations but is consistent with the definition of Remember/Know/New. The interpretation of findings from experiments using the Remember/Know paradigm and the models on which these interpretations should be based are hotly debated (e.g. Gardiner, Ramponi & Richardson-Klavehn, 2002; Macmillan, Rotello & Verde, 2005) and will not be described in detail here. Nevertheless, we may speculate that from a two-process theory of recognition memory which would propose that Remembering and Knowing reflect two different forms of memory process (e.g. Tulving, 1985) we might say that context is easier to remember than specific visual details. Whereas, from a single process theory which would propose that Remember and Know responses correspond to a different strength of memory drawing from signal detection theory (e.g. Donaldson, 1996) we might say that people have to be more confident in recognition to say they remember specific visual details of the context. One problem here is knowing exactly how participants interpreted the RKN instructions. Instructions for the RKN task have been found difficult to interpret and have been rewritten as Type 1 and Type 2 recognition rather than Recollection and Familiarity for use with people on the autistic spectrum (Bowler, Gardiner & Grice, 2000). This is in contrast to the SSN task where the instructions are easy to follow.

In conclusion, the Same/Similar/New task has been shown to be perhaps a cleaner test of memory than the Remember/Know/New task with clear and well-defined criteria by which participants should choose their responses. The SSN task therefore appears to be an appropriate experimental paradigm with which to continue the investigation of emotion's influence on memory. This SSN paradigm will be used in the next two experimental chapters of this thesis.

Chapter 4. The influence of emotion on specific visual details of memory

Chapter Introduction

In this chapter we continue to use the Same / Similar / New paradigm (Kensinger et al., 2006) to explore the influence of emotion on memory for the specific visual details of stimuli. For the remainder of the thesis we will be using this paradigm to start to explore the influence of emotion at the time of encoding new information into memory. By examining the information on which a memory is based, Kensinger et al. (2006) addressed the controversy in the literature over whether emotion leads to an increase in memory for details, or for gist at the expense of memory for details (e.g. Adolphs et al., 2005). In a series of studies, Kensinger and colleagues investigated the level of detail contained within memories for emotional stimuli by testing recognition memory for specific details and gist (Kensinger et al., 2006; Kensinger et al., 2007a, 2007b).

Whilst the enhancement for negative emotion was found in a series of studies the effects of positive emotions have not been studied so extensively. To our knowledge, memory for details of positive stimuli has only been investigated in a single study which found no enhancement in a younger college student sample, although a comparison group of older adults did show an enhancement in general memory of positive stimuli (Kensinger et al., 2007a). Kensinger et al. (2007a) argued that an enhancement of memory for details of negative, but not positive, emotional stimuli is consistent with research showing that positive emotion leads to more gist-based processing, whereas negative emotion leads to more detailed processing (Bless et al., 1996;

Levine & Bluck, 2004; Storbeck & Clore, 2005). Whilst there is some empirical support for this idea, for example from research into memory for autobiographical life events (e.g. Berntsen, 2002), it is not consistent with a number of studies which have shown an enhanced memory for positive items (Dewhurst & Parry, 2000; Dolcos et al., 2005; for a different interpretation see Dougal & Rotello, 2007; Ochsner, 2000). There are therefore inconsistencies in the literature on the effects that negative and positive emotions have on memory.

Section 2. Experiment 5: Visual memory specificity for negative and positive objects

Section 2.1. Introduction

Kensinger et al. found an effect of enhanced visual memory specificity in a series of experiments (Kensinger et al., 2006, 2007a, 2007b) using the same set of stimuli. The aim of this experiment is to test the effect of either valence of emotion and establish the findings of this paradigm before beginning a series of experiments to investigate the processes underlying this effect. According to Kensinger et al. we would expect to see enhanced visual memory specificity for negative, but not positive stimuli.

Section 2.2. Method

Design

In this experiment the effect of a factor of emotion with three levels (negative, positive, neutral) is examined on two measures of visual memory: specific recognition and general recognition. Participants were shown negative, positive and neutral stimuli in a within-participant mixed-list design.

Participants

Twenty-four participants took part in this experiment (13 Female). All were native English-speaking University of Nottingham students (mean age = 20.71 years, SD = 1.65). Informed consent was obtained from all participants. Participants received an inconvenience allowance of £6 for their voluntary participation. The School of Psychology, University of Nottingham Ethics Committee gave approval for the study.

Materials

The stimuli used in this experiment were selected from the same initial set of 405 pairs of photographs of objects which were reported in Chapter 3, Experiment 4. A new set of participants rated the stimuli for emotion, as in Experiment 4 this only included negative and neutral photographs, whereas positive photographs were also included in the emotion ratings given for this experiment. The ratings of perceptual features and familiarity were taken from those given by participants for Experiment 4. A different final subset of photographs were used for the experimental stimuli in Experiment 5 than in Experiment 4. This was due to the need to ensure only one pair of each type of object was included across positive, negative and neutral stimuli. The means and standard deviations given are for the 285 pairs (95 each of negative, neutral, positive) of stimuli included in this experiment. See Figure 4.1 for an example of pairs of stimuli.

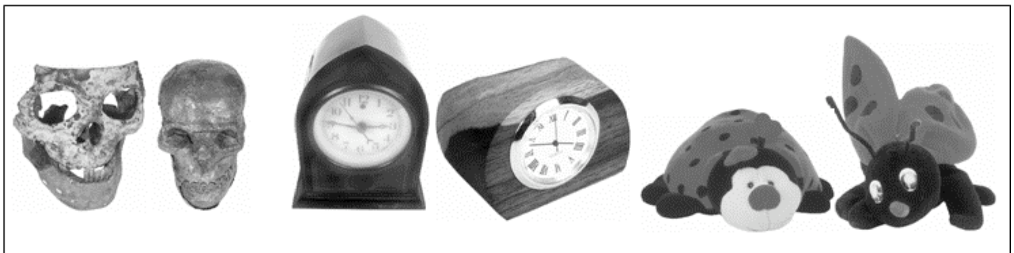


Figure 4.1. Examples of pairs of negative, neutral and positive objects used in Experiment 5. These were presented in colour for the experiment.

Emotion ratings.

There were 810 photographs of objects (405 pairs) rated individually for valence and arousal on an 11-point scale, from -5 (*negative*) to +5 (*positive*) and -5 (*calming / soothing*) to +5 (*exciting / agitating*) respectively. Participants were told to base their ratings on their initial reaction to the objects in the photographs. Twenty University of Nottingham students conducted the ratings (15 female; Mean age: 20.15 years, SD 0.75). The negative, neutral and positive groups of stimuli were given distinct mean average item ratings (with range and standard deviation in parentheses) for valence of -2.37 (-4.35 to -0.50; 0.90), 0.60 (-0.45 to 1.55; 0.46) and 2.36 (1.55 to 3.45; 0.41) and for arousal of 1.91 (0.70 to 3.53; 0.65), -0.26 (-0.45 to 0.5; 0.41) and 0.65 (-1.65 to 2.55; 0.97) respectively.

Perceptual features

i) Similarity.

There were 405 pairs of photographs of objects rated for similarity between the items in a pair by 10 University of Nottingham students (7 female; Mean age: 26.80 years, SD 3.46 years). Each pair was rated on a scale of 1 (*items incredibly similar*) to 10 (*items incredibly different*). The average ratings of similarity between items were comparable between the negative, neutral and positive object pairs with item means (with standard deviation in parentheses) of 3.40 (1.39), 4.09 (1.26) and 3.59 (1.32) respectively.

ii) Dimensions of change.

There were 405 pairs of photographs of objects rated for the dimensions that could differ between the two items in the pair (colour, shape, size, orientation) by two University of Nottingham students (2 female; Mean age: 27.50 years). A rating of 0 indicated that no change in a particular dimension occurred (e.g., if both pumpkins were orange); a rating of 0.5 indicated a slight change in a dimension (e.g., a light green pine tree versus a dark green pine tree) and a rating of 1 indicated a substantial change (e.g., a red apple versus a green apple). Average ratings of how these dimensions changed between the items in a pair were comparable between the different emotional groups. The item means (with standard deviations in parentheses) for negative, neutral and positive object pairs were: for colour .46 (.34), .68 (.31) and .56 (.37); for orientation .61 (.35), .55 (.34) and .55 (.37); for shape .44 (.29), .42 (.27) and .38 (.28); and for size .21 (.24), .20 (.24) and .20 (.25) respectively.

iii) Size.

There were 405 photographs of objects (1 item from each pair) rated for size by one University of Nottingham student (Female, 20 years). Thirty-eight percent of all the experimental stimuli were judged to fit into a shoebox in real life. This was similar across groups of negative (34 items), neutral (39 items) and positive stimuli (38 items).

Familiarity

i) Word frequency and word familiarity.

Word frequency and word familiarity (Wilson, 1988) for the 405 verbal labels of the object pairs were comparable between the negative, neutral and positive groups of stimuli. The average ratings (standard deviation in parentheses) for negative, neutral and positive stimuli were for verbal word frequency 68.24 (151.53), 67.73 (195.21) and 63.86 (75.97) and for word familiarity 394.34 (243.83), 430.95 (227.43) and 469.64 (224.37) respectively.

ii) Familiarity of object.

There were 405 photographs of objects (1 item from each pair) rated for familiarity on a scale of 1 (*highly unfamiliar*) to 10 (*highly familiar*) by one University of Nottingham student. Mean average item ratings (with standard deviations in parentheses) were comparable for negative, neutral and positive objects and were 4.41 (2.43), 4.48 (3.74) and 3.94 (3.76) respectively.

Procedure

Study.

Participants were presented with 228 nameable, colour photographs of objects (76 negative, 76 neutral, 76 positive). Items were presented for 500 ms with a variable inter-stimulus interval of between 6 and 14 seconds, which was randomly determined for each item. Participants were presented with a photograph, then had to make a task decision during the inter-stimulus interval whilst a central fixation cross was displayed. In this task participants had to indicate by key press (1 = Yes, 0 = No) whether in the real world the object would fit inside a shoebox, which was placed next to participants throughout the experiment. This was the task used by Kensinger et al. (2006) and ensured that, with the short presentation times of stimuli, participants did encode and process each object. The order of items was pseudorandomised so that no more than four items of one emotion were presented sequentially.

Test.

After an interval, of at least two days, participants completed a surprise recognition test. Participants were presented with three types of stimuli: *same,* photographs of objects that were exactly the same as those at study; *similar,* objects shared same verbal label but were not identical to those at study; and *new,* objects that had not previously been presented. Each object was presented centrally on the screen and participants were prompted to indicate by key press whether the item was *same*, *similar* or *new*. Participants were then asked to indicate their level of confidence in this decision (low or high) by pressing correspondingly labelled keyboard keys. Items were presented in a randomised order. A total of 114 items were shown that were the *same* at study and test, 114 items were shown that were *similar* to those shown at study (i.e. the other item from the object pair) and 57 items were shown that were new. One third of each of the *same*, *similar* and *new* items were negative, neutral or positive. All participants were presented with exactly the same photographs at test, whether these items were the *same*, *similar* or *new* for each participant was counterbalanced by varying the item of the object pair and the stimuli lists which were shown at study. To enable counterbalancing the items were presented across four lists with 57 items in each list (19 negative, 19 neutral, 19 positive). A fifth list of items was shown only at test. At the time of debriefing 22 participants confirmed they were not expecting to have their memory tested. Two participants were not sure. Overall memory performance from those who were not sure if there was going to be a memory test was comparable to that of the rest of the group.

Section 2.3. Results

The data for this experiment are presented in table 4.1 with the proportion of items given a ‘same’, ‘similar’ or ‘new’ response reported as a function of item type (*same*, *similar* or *new*) and emotion of object (negative, neutral or positive)[1]. Memory for specific visual detail was analysed in line with Kensinger et al. (2006) by calculating specific recognition defined as ‘same’ responses and general recognition defined as ‘same’ + ‘similar’ responses to items that were the *same* at study and test (See Figure 4.2). Analyses of Variance were conducted to examine whether the emotion of the items influenced specific recognition and general recognition. When assumptions for sphericity are not met this is shown by degrees of freedom with decimal places. In these instances the Greenhouse-Geisser adjusted *p* values are reported. Planned contrasts were conducted to compare recognition for emotional vs. neutral stimuli and then negative vs. positive stimuli.

[1] The level of chance for correct recognition performance was 40% for *same* and *similar* items. i.e. 40% chance of giving ‘same’ response to *same* item. It was 20%for *new* items. There were 114 *same* items, 114 *similar* items and 57 *new* items.

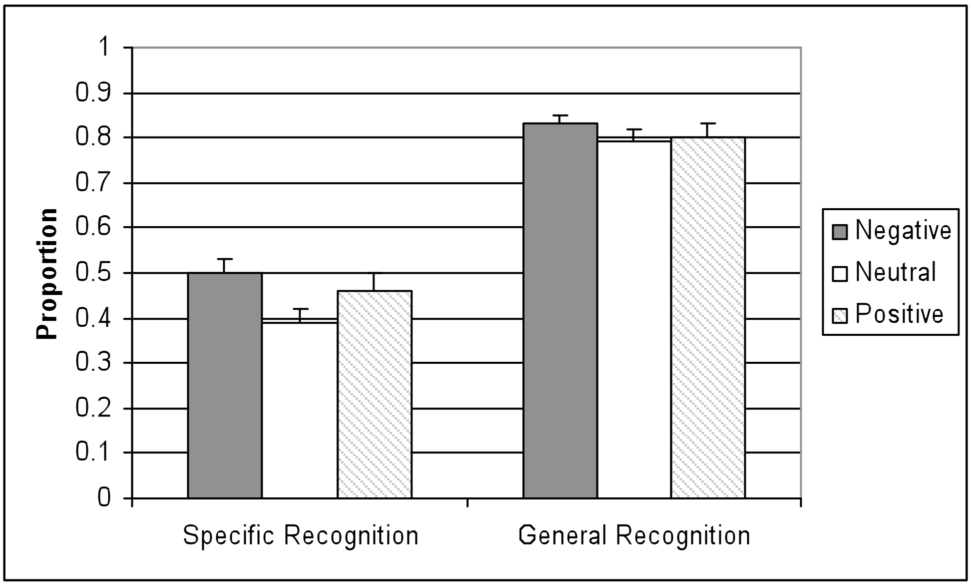


Figure 4.2. Mean average specific and general recognition to negative, neutral and positive objects (+SE). Specific recognition was enhanced by both negative and positive emotion, but there was no emotional enhancement for general recognition.

Table 4.1. Experiment 5: Proportion of same/similar/new items given ‘same’/‘similar’/‘new’ responses (Mean, S.E.) for negative, neutral and positive objects

	Same items	Similar items	New items
Response type:		Negative objects	
‘Same’	.50 (.03)	.17 (.02)	.02 (.01)
‘Similar’	.34 (.02)	.49 (.03)	.22 (.03)
‘New’	.17 (.02)	.34 (.04)	.76 (.03)
		Neutral objects	
‘Same’	.39 (.03)	.13 (.02)	.04 (.02)
‘Similar’	.40 (.03)	.44 (.04)	.21 (.03)
‘New’	.21 (.03)	.44 (.04)	.75 (.04)
		Positive objects	
‘Same’	.46 (.04)	.15 (.02)	.03 (.01)
‘Similar’	.33 (.02)	.46 (.03)	.21 (.03)
‘New’	.21 (.03)	.39 (.04)	.76 (.03)

The ANOVA on general recognition revealed no significant main effect of the factor emotion [$F_{(2,46)} = 2.09$, MSE = 0.02, $p = .14$, $\eta_p^2 = .08$]. The ANOVA on specific recognition did reveal a significant main effect of the factor emotion ($F_{(2,46)} = 8.33$, MSE = .07, $p<.001$, $\eta_p^2 = .27$). Planned contrasts on the factor of emotion revealed a significant difference between specific recognition of emotional and non-emotional stimuli ($F_{(2,46)} = 14.91, p<.01$) but not between positive and negative stimuli [$F_{(2,46)} = 1.58, p = .22$]. This reflected an enhancement of specific recognition for both positive and negative stimuli with no significant difference in the level of enhancement between the two valences of emotion.

The emotional content of items did not affect the distribution of confidence ratings. ANOVAs conducted on the high confidence responses alone for the *same, similar* and *new* items revealed the same pattern of main effects and interactions as when the analysis was conducted on all of the responses collapsed across confidence levels. Therefore, the confidence ratings will not be discussed further. The possibility of a response bias towards giving an incorrect 'same' response to emotional, rather than neutral, items was checked by analysing responses to new items, which had not been seen before the recognition test. A 3 (emotion) x 3 (response type) ANOVA found no evidence for such a response bias.

Section 2.4. Discussion

An enhancement of visual memory specificity for positive and negative emotional stimuli was found relative to neutral stimuli. There was no emotional enhancement of general recognition. Our findings of an enhancement of specific, but not general, recognition for negative emotional stimuli are consistent with those of Kensinger et al. (2006, 2007a) who investigated negative arousing and neutral stimuli. However, the finding of a positive emotional enhancement of specific recognition is not consistent with earlier research by Kensinger et al. (2007a) who did not find an enhancement of memory for positive stimuli. These findings are not easily explained by arguments that negative emotions lead to an analytical style of processing and therefore heightened memory for details, whereas positive emotions lead to a more heuristic style of processing and no enhancement in memory for details (Kensinger et al., 2007a). If this were the case we would not have expected to find an enhancement of specific recognition for positive objects. In conclusion, we have demonstrated that visual memory specificity can be enhanced by both positive and negative emotional content. It is not clear whether attentional narrowing could explain these results and so Experiment 6 was conducted to further examine this possibility.

Section 3. Experiment 6: Central-peripheral trade-offs in visual memory specificity for scenes

Section 3.1. Introduction

Visual memory specificity for positive and negative emotional objects, in comparison to neutral objects, was demonstrated in Experiment 5.

One way to examine inconsistencies that have been found in the memory literature of effects that positive and negative emotions have on memory is to consider emotions' effects on memory for different elements of a scene. Emotion has been shown to have different effects on memory for central compared to peripheral details of a scene. For example, in a scene of a person being attacked on a street, details of the attacker would be central to the scene, whereas details of a car parked in the street would be peripheral to the scene. In comparison to memory for a neutral event, memory for central details of an emotional event was enhanced whilst memory for peripheral details was impaired (Christianson & Loftus, 1991). This trade-off may be the result of negative emotional arousal causing a narrowing of attention on to details associated with the emotional item, which are closely attended to and therefore later remembered, whilst information that is peripheral to the emotion is not attended to (cf. Easterbrook, 1959) and therefore likely to be forgotten. Kensinger et al. (2007b) interpreted this as support for the role of attention-focusing at the time of encoding in the emotional enhancement of memory. They tested their interpretation by presenting objects as part of a contextually relevant scene and found a central-peripheral trade-off in specific and general recognition memory for negative emotional stimuli relative to neutral stimuli, with an enhancement in memory for the negative object (central element) associated with a detriment to memory for the background on which the object was presented (peripheral element). Kensinger et al. (2007b) further investigated the role of attention in this central-peripheral trade-off by giving participants task instructions which directed their attention to central and peripheral aspects of the scene and showed that this eradicated the trade-off by increasing memory for the peripheral details. They argued that these findings support the idea that within natural viewing conditions, attentional processes at encoding play an important role in emotional enhancement of visual memory specificity.

This possibility will be investigated further by examining visual memory specificity for objects and the neutral backgrounds on which they will be presented. This experimental paradigm is adapted from Kensinger et al. (2007b) who investigated memory for negative and neutral objects that were placed on neutral backgrounds. The aim of this experiment is to examine whether visual specificity for positive and negative objects remains when they are presented on neutral backgrounds and form part of a more ecologically valid scene than the objects presented in isolation in Experiment 5. A further aim is to consider if the emotional effects could be explained by attention narrowing at encoding which would be suggested by better memory for the central emotional object at the expense of memory for the peripheral background. Alternatively, improved memory for the central emotional object and the neutral background together may suggest the enhancement results from a generalised increase in physiological arousal which could lead to an overall increase in efficiency of cognitive processing. Positive and negative emotions may influence memory through different routes and indeed while negative stimuli may lead to a narrowing of attention (e.g. Christianson et al., 1991), positive stimuli can lead to a broadening of attention (Fredrickson, 2001). We predict that we will find evidence for a central-peripheral trade-off in memory for negative stimuli.

Section 3.2. Method

Design

A within-participants design was used to examine the factors of emotion with three levels (negative, positive and neutral) and scene component with two levels (object or background) on two measures of memory; specific recognition and general recognition.

Participants

Eighteen participants took part in this experiment (10 female). All were native English speaking University of Nottingham students (mean age = 24.5

years, SD = 3.07). Participants received an inconvenience allowance of £3 for their voluntary participation. Informed consent was obtained from all participants.

Materials

Seventy-two scenes were created using the stimuli from Experiment 5 (photographs of objects) and additional pairs of photographs for neutral backgrounds of the scenes. The backgrounds were selected from internet databases of images (Google Images) and from photographs taken specifically for this experiment by the researcher. Scenes were created using one pair each of negative, neutral and positive objects where it made contextual sense for all the objects to be placed on the same background. 12 versions of each scene were created using pairs of backgrounds that had the same verbal label and a similar appearance (see Figure 4.3). Each version of the scene comprised one background from a pair, and one item from one of the object pairs. For example, one scene could have a background of a picket fence with a negative object of a sheep skull, or a neutral object of a tool box or a positive object of a lamb. By placing each object from the three object pairs (negative, neutral & positive object pairs) with either background 12 versions could be created. At test participants were shown the object and background components of a scene separately. When components of a *similar* version of a scene were presented to participants these could be of a similar object and/or background. Each version of one scene had approximately the same amount of background covered by the object.

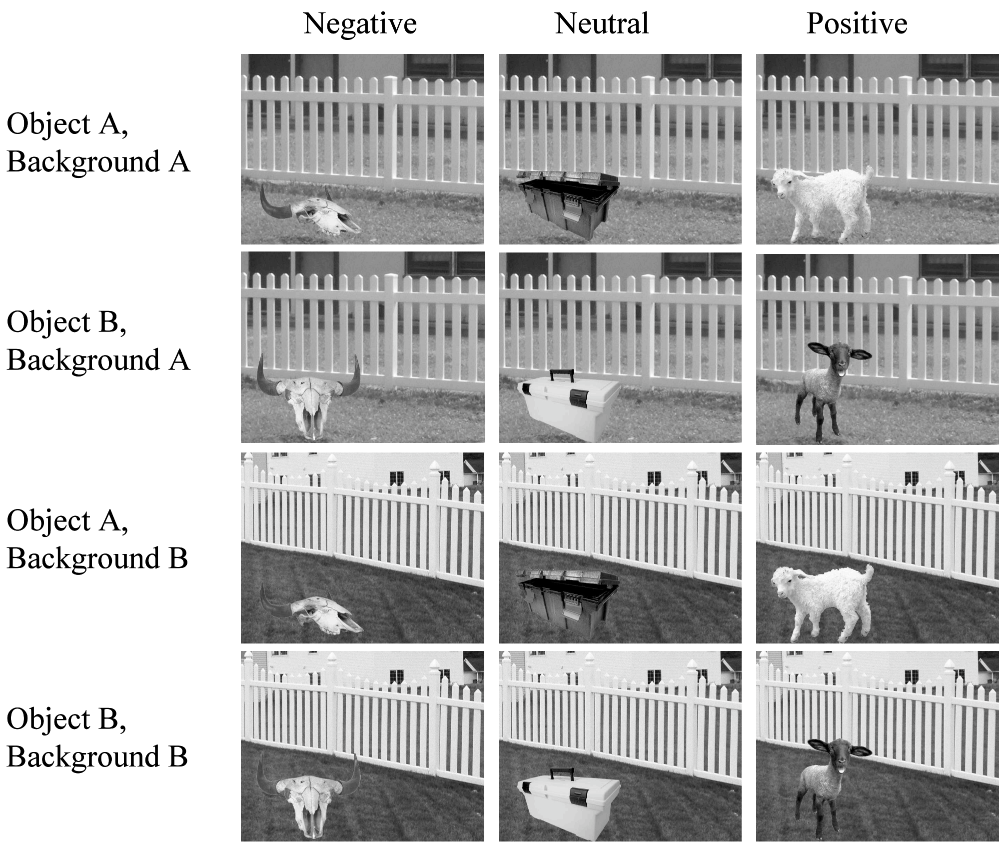


Figure 4.3. Examples of stimuli. Stimuli were shown in colour for the experiment. One pair each of negative objects, neutral objects, positive objects and neutral backgrounds were used to create 12 versions of each scene to allow counterbalancing of whether items shown at test were same, similar or new in comparison to items shown at study.

The ratings obtained for Experiment 5 were used to match the negative, neutral and positive groups of stimuli for ratings of perceptual features and familiarity and to provide distinct groups of emotional valence and arousal. It was more difficult to obtain close matches between the ratings of negative, neutral and positive object pair groups in this experiment than in Experiment 5 due to the necessity of ensuring that scenes were contextually and graphically congruent with a pair of negative, neutral and positive objects. Average ratings of how these dimensions changed between the items in a pair were comparable between different emotional groups. The item means (with standard deviations in parentheses) for negative, neutral and positive object pairs were: for orientation .62 (.33), .56 (.33) and .55 (.36); for shape .45 (.30), .42 (.28) and .37 (.28); and for size .22 (.24), .20 (.25) and .19 (.24) respectively. There were also comparable average mean ratings (with standard deviations in parentheses) between negative, neutral and positive object groups for similarity between objects within a pair 3.38 (1.38), 3.94 (1.30) and 3.75 (1.29); and for familiarity of the object 4.49 (2.40), 4.57 (3.82) and 3.93 (3.79) respectively. A comparable number of objects would fit into a shoebox for negative, neutral and positive emotion groups, these were 27, 31 and 26 respectively. The negative object pairs had a lower average rating for the change of colour between two items in a pair than the positive and neutral pairs, the average means (with standard deviations in parentheses) were .46 (.32), .62 (.32) and .60 (.36) respectively. Therefore, the colour of one item from each of 15 negative pairs (which had low ratings) was altered by adjusting the saturation levels of the red/green/blue channels in Adobe Photoshop. These adjusted pairs of items were rated for the dimension of change in colour by two participants and had a new overall average .56 (SD = .32) which was comparable to the ratings for neutral and positive object pairs.

The negative, neutral and positive objects all had distinct item mean average ratings (with range and standard deviation in parentheses) for valence -2.51 (-4.35 to -0.55; 0.81), .53 (-0.45 to 1.45; 0.46) and 2.33 (1.55 to 3.45; 0.41) and for arousal 1.97 (0.75 to 3.55; 0.64), -0.23 (-1.20 to 0.45; 0.36) and

0.59 (-1.65 to 2.55; 0.98) respectively. Backgrounds were rated by one participant on a scale from -5 (negative) to +5 (positive) for valence and -5 (*calming*) to +5 (*exciting*) for arousal and were given ratings for arousal in the range -1 to +1 and valence in the range -1 to +2. Verbal labels of the backgrounds were generated by two raters to ensure agreement and avoid any ambiguity between different pairs of backgrounds. It was crucial to the experimental design that participants considered only one specific object or background pair when completing the memory test. When two raters generated the same background label then this was chosen, when there was disagreement a third rater was consulted and the label generated by the majority of raters was chosen. Rater agreement for the verbal labels of the objects was not checked as these were not ambiguous.

Procedure

Study.

Participants were presented with 48 scenes composed of a neutral background and either a negative, neutral or positive object. Each scene was displayed for two seconds and participants then had to indicate by key press on a 1-7 Likert type scale whether they would like to move closer or further away from the scene. The scenes were presented in a pseudo-randomised order so no more than four scenes with the same type of emotion object were shown sequentially. (For results of study phase ratings see meta-analysis in Section 5.2, Chapter 5).

Test.

Participants completed a memory test after an interval of 30 minutes, during which time participants completed an unrelated experiment. For the memory test participants were presented separately with components of 72 scenes (i.e. the backgrounds and objects were presented separately). Each item was presented with a prompt above the picture asking the participant “Did you see a ________?” with the blank completed with the verbal label of the item. There was another prompt below the picture asking participants to indicate by key press whether the item was *same* / *similar* / *new* in comparison to items from the study phase. All items were presented in a random order with objects and backgrounds presented centrally on screen. 24 backgrounds and objects were exactly the *same* as those from the study phase, 24 backgrounds and objects were *similar* to those from the study phase (i.e. the other half of the object or background pair) and 24 backgrounds and objects were *new* and had not been shown previously in the experiment. One third of each of the *same*, *similar* and *new* objects were negative, neutral or positive. One third of each of the *same* or *similar* backgrounds had been displayed at study with a negative, neutral or positive object. Whether an item was *same* / *similar* / *new* at test was counterbalanced by altering which version of the scene participants had seen at study. Participants saw the components of only one version of each scene at test. Three sets of stimuli were used for the memory test, the set seen by each participant depended on the counterbalancing at study. At the time of debriefing 16 participants confirmed the memory test was a surprise, two participants were not sure. Overall memory performance from those who were not sure if there was going to be a memory test was comparable to that of the rest of the group.

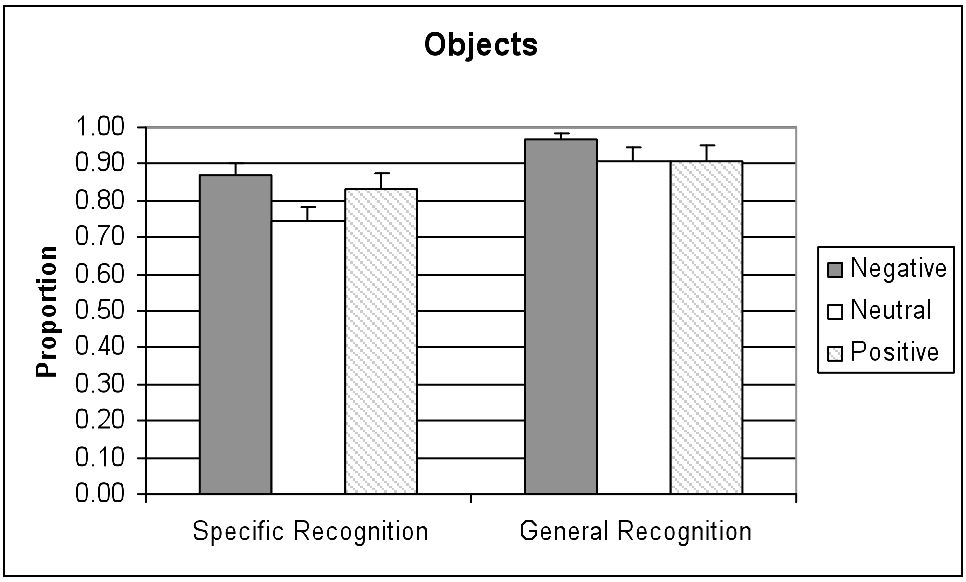
Section 3.3. Results

The data for this experiment are reported in Table 4.2 with the proportion of items given a ‘same’, ‘similar’ or ‘new’ response reported as a function of item type (*same*, *similar* or *new*), scene component (object or background) and emotion of object (negative, neutral or positive)[2]. (For statistical analysis of the responses given to different items (SSN) see Appendix 4.1.) The results were analysed by calculating specific recognition and general recognition in the same way as for Experiment 5 (see Figure 4.4). Repeated measures ANOVA were conducted on the data. All analyses reported are based on items that were the *same* at study and test. When assumptions for sphericity are not met this is shown by degrees of freedom with decimal places. In these instances the Greenhouse-Geisser adjusted *p* values are reported.

[2] The level of chance for correct recognition performance was 33% for each item type. i.e. 33% chance of giving ‘same’ response to *same* item. The level was the same for objects and backgrounds. There were 24 each of *same, similar* and *new* objects and backgrounds.

Table 4.2. Mean responses (SE) for objects and backgrounds as a function of item type (same, similar or new) and emotion type (negative, neutral or positive). For new backgrounds the same data appear in negative, neutral and positive as these backgrounds were not associated with any particular object.

	Item Type:					
	Same	Similar	New	Same	Similar	New
Response type:	Negative objects			Background (Negative)		
'Same'	.87 (.04)	.32 (.04)	.04 (.02)	.30 (.06)	.22 (.04)	.13 (.03)
'Similar'	.10 (.03)	.52 (.06)	.15 (.03)	.28 (.03)	.25 (.05)	.22 (.04)
'New'	.03 (.02)	.16 (.04)	.81 (.04)	.42 (.06)	.53 (.06)	.65 (.05)
	Neutral objects			Background (Neutral)		
'Same'	.74 (.04)	.27 (.05)	.04 (.02)	.44 (.06)	.18 (.03)	.13 (.03)
'Similar'	.17 (.03)	.45 (.06)	.15 (.03)	.23 (.03)	.37 (.05)	.22 (.04)
'New'	.09 (.04)	.28 (.06)	.81 (.03)	.33 (.07)	.45 (.05)	.65 (.05)
	Positive objects			Background (Positive)		
'Same'	.83 (.04)	.32 (.05)	.05 (.02)	.44 (.05)	.21 (.04)	.13 (.03)
'Similar'	.08 (.02)	.46 (.06)	.13 (.03)	.24 (.05)	.28 (.04)	.22 (.04)
'New'	.09 (.04)	.22 (.04)	.82 (.02)	.32 (.06)	.51 (.06)	.65 (.05)



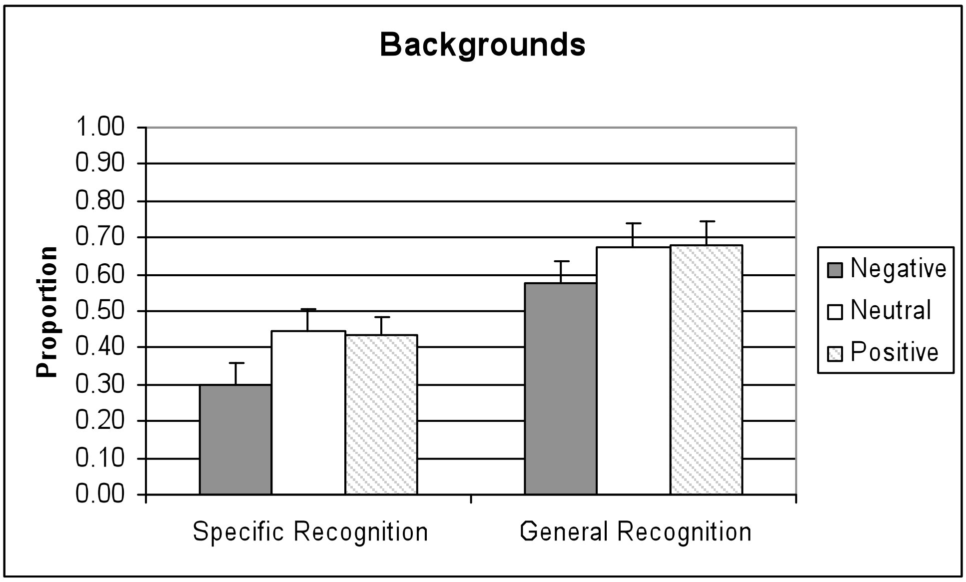


Figure 4.4. Mean average specific and general recognition to neutral backgrounds presented with negative, neutral or positive objects and negative, neutral or positive objects presented with neutral backgrounds (+SE).

Separate ANOVAs were conducted with specific recognition and general recognition. A 2 (scene component) x 3 (emotion) repeated measures ANOVA on specific recognition revealed a significant main effect of scene component with greater specific recognition for objects than backgrounds

($F_{(1,17)}$ = 81.94, MSE = 4.79, p<.001, η_p^2 = .83) and a significant interaction between scene component and emotion ($F_{(2,34)}$ = 6.83, MSE = 0.17, p<.01, η_p^2 = .29). There was no significant main effect of emotion [$F_{(2,34)}$ = 1.04, MSE = 0.03, p = .37, η_p^2 = .06]. Planned contrasts revealed the difference between specific recognition of backgrounds with worse recognition for those with an emotional than neutral object was approaching significance [$F_{(1,17)}$ = 4.19, p = .06] and there was significantly worse recognition for backgrounds with a negative than positive object($F_{(1,17)}$ = 4.86, p<.05). For the objects there was significantly greater specific recognition of emotional than neutral objects ($F_{(1,17)}$ = 9.70, p<.01) but no significant difference between positive and negative objects [$F_{(1,17)}$ = 0.30, p = .59].

A 2 (scene component) x 3 (emotion) repeated measures ANOVA on general recognition revealed a significant main effect of scene component with greater recognition for the objects than for the backgrounds ($F_{(1,17)}$ = 29.13, MSE = 2.19, p<.001, η_p^2 = .63). There was no significant main effect of emotion [$F_{(2,34)}$ = 0.27, MSE = 0.01, p = .77, η_p^2 = .02] but the interaction between scene component and emotion was approaching significance [$F_{(2,34)}$ = 3.18, MSE = 0.07, p = .05, η_p^2 = .16]. Planned contrasts revealed no significant difference between general recognition of backgrounds with emotional or neutral objects [$F_{(1,17)}$ = 0.62, p = .44], although the worse general recognition for backgrounds with negative than positive objects was approaching significance [$F_{(1,17)}$ = 3.40, p = .08]. There was no significant difference between recognition of neutral vs. emotional objects [$F_{(1,17)}$ = 0.94, p = .35] nor between positive and negative objects [$F_{(1,17)}$ = 1.86, p = .19].

The possibility of a response bias towards giving an incorrect 'same' response to emotional, rather than neutral, items was checked by analysing responses to new items, which had not been seen before the recognition test. Analyses using 3 (emotion) x 3 (response type) ANOVAs were carried out separately for recognition of the objects and backgrounds and found no evidence for such a response bias.

Section 3.4. Discussion

An enhancement of specific recognition was found for both positive and negative objects with impairment for backgrounds only for scenes with a negative object. There was no emotional enhancement for memory of objects in general recognition[3], although an impairment in memory for backgrounds with negative objects did approach significance, suggesting the central-peripheral trade-off is more pronounced when measuring specific, than general, recognition. The central-peripheral trade-off in specific recognition with negative emotion suggests that attention narrowing onto the negative objects may explain this enhancement of specific recognition of negative objects. Conversely, the lack of central-peripheral trade-off with positive emotion suggests that factors other than attentional focus at the time of encoding are needed to explain this effect.

These findings of negative and positive emotional enhancement for the memory of objects presented on a neutral background are similar to those of Experiment 5 when objects were presented in isolation. A shorter time delay

[3] There was a near ceiling effect in general recognition of objects which may have prevented any emotional enhancement of this measure from being found. The general recognition of backgrounds was much lower than of objects and therefore allowed emotional influences to be found.

was used between the study and test phase for Experiment 6 than Experiment 5 to produce similar levels of memory performance even with the more complex stimuli used and to avoid floor effects in memory for the background. The same pattern of emotional effects on object memory was shown after the 30 minute delay in Experiment 6 as after the delay of at least 2 days in Experiment 5.

Our findings of a central/ peripheral trade-off for specific and general recognition with a negative emotional enhancement for objects and impairment for backgrounds are consistent with those of Kensinger et al. (2007b). Although, again, our finding of positive emotional enhancement for specific recognition of objects is not consistent with Kensinger's earlier research, the lack of peripheral impairment for memory of backgrounds with positive objects is consistent with proposals that positive emotion may lead to a broadening of attention (Fredrickson, 2001; Freitas et al., 2008; Kensinger et al., 2007a; Rowe et al., 2007).

In conclusion, the central/peripheral trade-off in specific recognition suggests that the negative emotional enhancement of visual memory specificity may be due to attentional factors at encoding but that positive emotional enhancement of visual memory specificity is not. This will be investigated more directly in Experiment 7.

Section 4. Experiment 7: Biases in spatial distribution of attention at the time of encoding

Section 4.1. Introduction

Negative emotion can have different effects on memory for the details of central and peripheral elements of visual scenes and these are modulated by time and task instructions. These effects could be interpreted as indicating that factors at the time of encoding are involved in the emotional enhancement of memory. Kensinger et al. (2006) suggested that attentional effects may contribute to this emotional enhancement in two different ways. One possibility is that the automatic and preferential focus of attention onto emotional stimuli (e.g. Ohman, Flykt, & Esteves, 2001) may lead to more automatic encoding of visual details for emotional than neutral items. An alternative is a more controlled process in which participants focus more of their attention on the task with negative items.

Kensinger et al. (2007b) explored the influence of attention on the emotional enhancement of memory by manipulating task instructions and interpreted the results as indicating that attentional processes had been affected (Kensinger et al., 2007b). This interpretation, however, is not directly supported by providing any actual measure of attentional processes. We propose to explore participants' attentional strategies during the task; if attentional strategy is related to central-peripheral trade-offs it would provide direct evidence for Kensinger et al.'s speculation; however, if attentional strategy is not related to central-peripheral trade-offs it would severely weaken Kensinger et al.'s interpretations. One method of exploring the distribution of attention across stimuli is to measure the eye movements people make when viewing stimuli and examine how these relate to their subsequent memory. Eye movements have been argued to provide a behavioural indication of the allocation and location of attention (e.g. Henderson, 2003) when participants engage in tasks that resemble real-life interactions. Although, it is possible to create specific task parameters in a controlled laboratory setting that show attention shifts without the need for eye movement (e.g. Posner, 1980). It is broadly argued that in naturalistic scene viewing visual attention is closely indexed by eye movements (e.g. Land & Tatler, 2009). Our task resembles the naturalistic viewing of scenes, and under these circumstances, we believe that recorded eye movements provide a good index of visual attention.

The theory that attention influences the emotional enhancement of memory has been previously investigated by measuring eye movements at a time when the technology had first become available and this showed that attention was an associated, but not necessary, condition for the influence of emotion on memory (Christianson et al., 1991). Christianson et al. (1991) found that participants had an enhanced memory of the central object of an upsetting event relative to a neutral event, and that this was associated with a greater number of fixations on the central object in the upsetting event than in the neutral event. This shows an association of attention with the memory enhancement process. The emotional enhancement of memory remained, however, even when the distribution of attention was controlled across emotional and neutral conditions by restricting participants to only one eye fixation on the critical slide and directing participants to look at the same detail in both conditions. This indicates that attention is not a necessary condition for emotion to influence memory. Christianson et al. (1991) proposed that, instead of an attentional encoding explanation, either pre-attentive processing or post-stimulus elaboration could explain the results; however, support for these theories has not been found (Hulse, Allan, Memon, & Read, 2007; Libkuman, Stabler, & Otani, 2004). Although at the time Christianson et al.'s (1991) research was pioneering in the measure of eye movements, the technology limited the design in a number of ways; it allowed analysis of eye movements on only one critical scene per participant, and the number, position and location of eye fixations had to be determined by watching a slow motion video of the scene with the fixation spot superimposed onto the original stimuli and manually indicating whether fixations were central or peripheral to the scene and indicating the start/stop time for fixations. This methodology may have reduced accuracy of the eye movement measurements, and in combination with data from only one viewing instance per participant, may limit the generalisability of the findings.

Christianson et al. (1991) provided some measure of categorical comparison between memory for central and peripheral aspects of the scene, but the involvement of attention in memory for details within those categories is still not clear and a number of predictions could be made from previous literature. The research by Kensinger and colleagues using memory specificity paradigms is a rare example in the literature of a systematic examination of the influence of emotion on memory. We will measure attention at the time of encoding to examine how the spatial distribution of attention is involved in this emotional enhancement of memory. Based on Kensinger's research and arguments that negative emotions lead to a narrowing of attention whilst positive emotions lead to a broadening of attention (Fredrickson, 2001; Freitas et al., 2008; Kensinger et al., 2007a; Rowe et al., 2007) we would predict that eye movement measurements will reflect greater attention on negative than neutral or positive objects, with less attention on backgrounds with negative than neutral or positive objects.

Attention at the time of encoding has previously been examined using divided attention tasks to assess the amount of attentional capacity required for the emotional enhancement of memory (e.g. Kern et al., 2005; Talmi et al., 2007) but these studies have not been able to assess the relative distribution of attention to central and peripheral elements of stimuli, which the measurement of eye movements will allow. Eye movements enable us to record several different measurements: total gaze duration as a measure of the amount of time people look at different components of a scene, number of fixations to indicate the amount of eye movements people make when looking at different components of a scene and average fixation duration as a more sensitive measure of processing difficulty where longer durations are often found with more complex stimuli. Research into reading has shown that words which are rarely encountered have longer average fixation durations than words which are commonly encountered (Rayner & Pollatsek, 1989), suggesting that average fixation duration reflects processing difficulty.

The aim of this experiment is to examine whether the central/peripheral trade-off found with negative, but not positive or neutral, scenes in Experiment 6 could be explained by attentional effects at encoding. We predict that for negative objects people will tend to look for a greater amount of time at the object than the background, but that any such bias will be reduced or absent for neutral and positive stimuli. We predict that the same pattern of memory results will be found as for Experiment 6 with a central/peripheral trade-off for negative, but not neutral or positive, stimuli. We hypothesise that a central/peripheral trade-off in memory for scenes containing negative objects will be associated with attentional effects at encoding.

Section 4.2. Method

Design

A within-participants mixed list design was used with scenes of a neutral background and either a negative, neutral or positive object to examine participants' eye movements at the time of encoding.

Participants

Twenty-one participants were tested but data from 3 were excluded as their eye movement data did not record accurately (see Results for details). Data from 18 participants (11 female) is included in the analysis. All participants were native English speaking University of Nottingham students (mean age = 20.11 years, SD = 4.90). Informed consent was obtained from all participants. Participants received an inconvenience allowance of £4 for their voluntary participation.

Materials

The same stimuli were used in this experiment as in Experiment 6. The location of some of the objects in the scenes was altered from Experiment 6 to counterbalance the location of the object in the scenes; for 50% of trials the object was located centrally (in the same location as the pre-trial fixation cross) and for 50% of trials the object appeared at a non-central location, requiring participants to make an eye movement to fixate on the object and away from the fixation cross. A Sensorimotoric iViewX Remote Eye-tracking Device was used to measure eye movements. Eye-tracking measurements were recorded at 50 Hz (a recording taken every 20 milliseconds) using a computer provided by Sensorimotoric. The experiment was run using E-Prime on a Compusys PC with a 17" CRT monitor and a screen resolution of 1024 by 768 pixels. Participants sat with their head resting on a chin rest and a rounded bar forehead rest, with the chair height adjusted to a position comfortable for them. The monitor was placed 60cm from the participant. The visual angle subtended by the monitor was 30 horizontally and 23 vertically.

Procedure

Study.

The procedure of the experiment was the same as Experiment 6 with a few alterations to allow for the recording of participants' eye movements during the study phase. Responses in the approach/avoidance task during the study phase were made by a mouse click on a visual scale instead of a key press as in Experiment 6. This was to minimise head movements and subsequent interference with eye movement recordings. Participants were told that the purpose of the study was to investigate how people perceive pictures and their eye movements would be recorded but they should view the pictures as they would normally. Participants were given task instructions on computer and their eye movements were calibrated in the eye-tracker. Participants first completed the task with five example scenes to allow them to get used to the eye-tracker and provide the opportunity to re-calibrate if necessary. These scenes were drawings of landscapes and differed in appearance from the experimental photographic stimuli. Participants were instructed to keep their head as still as possible whilst they were completing the task. A fixation cross of one second was displayed before and after each picture to aid with recording of eye movements. After the practice participants' eye movements were re-calibrated and the main experiment began. Participants were presented with 48 scenes, of which one third each of the objects were negative, neutral or positive. The same counterbalanced lists of experimental stimuli were used as in Experiment 6. (For results of study phase ratings see meta-analysis in Section 5.2, Chapter 5).

Test.

After an interval of 30 minutes, the test phase was conducted with exactly the same procedure as in Experiment 6. At the time of debriefing 13 participants confirmed that the memory test was a surprise and 5 participants were not sure. Overall memory performance from those who were not sure if there was going to be a memory test was comparable to that of the rest of the group.

Section 4.3. Results

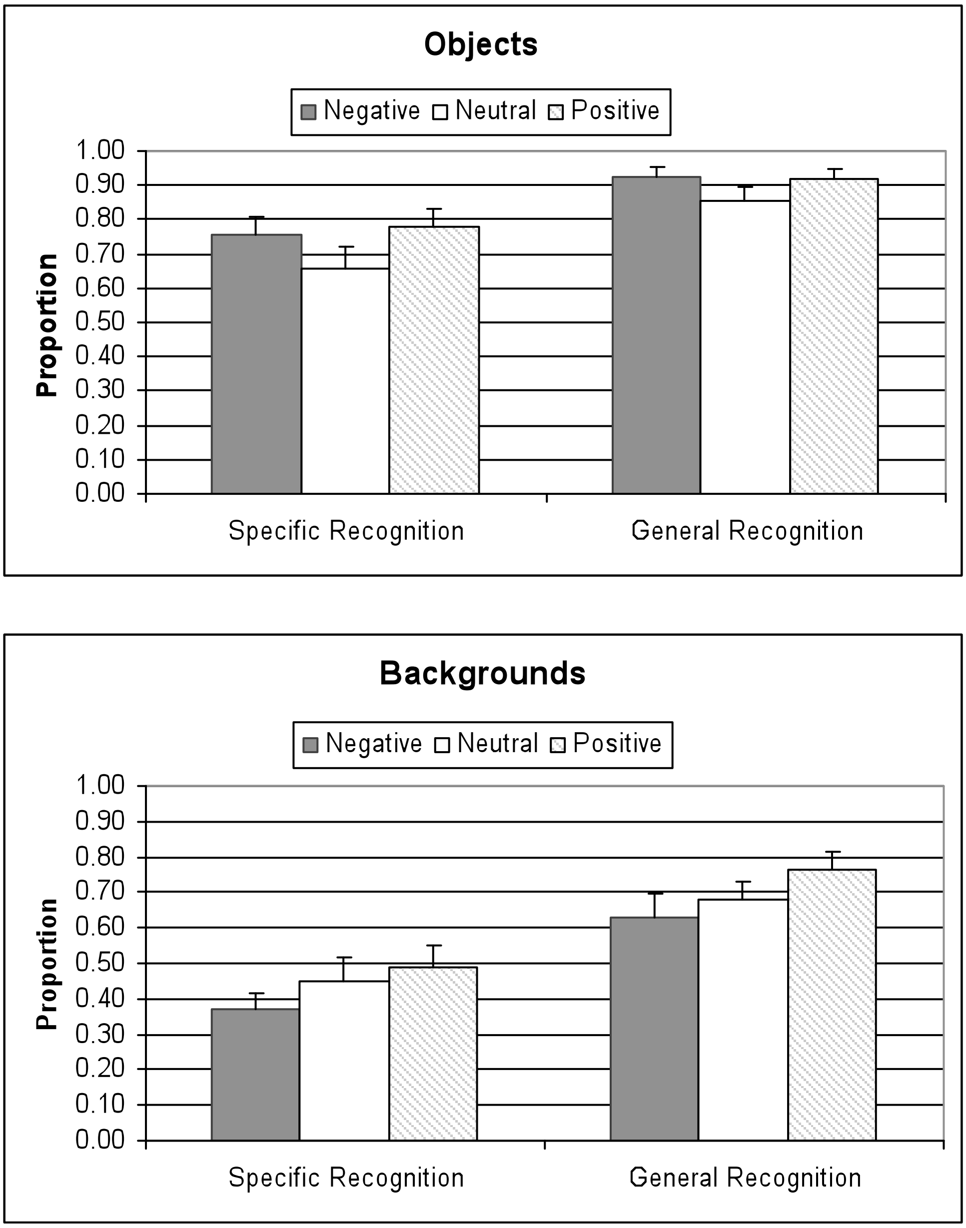
Memory Results

Analysis of the memory data from Experiment 7 was conducted in the same way as for Experiment 6 (See Table 4.3 and Figure 4.5). (For statistical analysis of the responses given to different items see Appendix 4.1.) A 2 (scene component) x 3 (emotion) repeated measures ANOVA on specific recognition revealed a significant main effect of scene component with greater specific recognition for the objects than backgrounds ($F_{(1,17)}$ = 22.63, MSE = 2.37, p<.001, $_{p}^{2}$ = .57). There was no significant main effect of emotion [$F_{(2,34)}$ = 2.08, MSE = 0.06, p = .14, $_{p}^{2}$ = .10] but the interaction between scene component and emotion approached significance [$F_{(2,34)}$ = 3.20, MSE = 0.07, p

= .05, η_p^2 = .159]. Planned contrasts revealed no significant difference between recognition of backgrounds with neutral or emotional objects [$F_{(1,17)}$ = 0.30, p = .59], although the worse recognition for backgrounds with a negative than positive object did approach significance [$F_{(1,17)}$ = 3.37, p = .08]. There was significantly greater recognition of emotional than neutral objects ($F_{(1,17)}$ = 4.50, $p<.05$) but no significant difference between recognition of negative and positive objects [$F_{(1,17)}$ = 0.25, p = .63].

Table 4.3. Mean responses (SE) for objects and backgrounds as a function of item type (same, similar or new) and emotion type (negative, neutral or positive). For new backgrounds the same data appears in negative, neutral and positive as the backgrounds were not associated with any particular object.

	Item type:					
	Same	Similar	New	Same	Similar	New
Response type:	Negative objects			Background (Negative)		
'Same'	.76 (.05)	.28 (.04)	.03 (.02)	.37 (.05)	.23 (.03)	.07 (.17)
'Similar'	.17 (.04)	.56 (.06)	.22 (.04)	.26 (.04)	.36 (.04)	.21 (.03)
'New'	.08 (.03)	.16 (.04)	.74 (.05)	.37 (.06)	.41 (.05)	.72 (.04)
	Neutral objects			Background (Neutral)		
'Same'	.66 (.06)	.26 (.04)	.03 (.02)	.45 (.06)	.19 (.04)	.07 (.17)
'Similar'	.19 (.03)	.44 (.06)	.17 (.04)	.23 (.03)	.41 (.03)	.21 (.03)
'New'	.15 (.04)	.30 (.07)	.80 (.04)	.32 (.05)	.40 (.04)	.72 (.04)
	Positive objects			Background (Positive)		
'Same'	.78 (.05)	.31 (.05)	.03 (.01)	.49 (.06)	.17 (.04)	.07 (.17)
'Similar'	.14 (.03)	.49 (.06)	.13 (.03)	.28 (.05)	.39 (.05)	.21 (.03)
'New'	.08 (.03)	.19 (.04)	.84 (.04)	.24 (.05)	.44 (.05)	.72 (.04)



<u>Figure 4.5. Mean average specific and general recognition to neutral backgrounds presented with negative, neutral or positive objects and negative, neutral or positive objects presented with neutral backgrounds (+SE).</u>

A 2 (scene component) x 3 (emotion) repeated measures ANOVA on general recognition revealed a significant main effect of scene component with greater recognition for the objects than backgrounds ($F_{(1,17)} = 18.29$, MSE = 1.15, $p<.001$, $_p^2 = .52$). There was no significant main effect of emotion [$F_{(2,34)} = 2.62$, MSE = 0.06, $p = .09$, $_p^2 = .13$]. There was a significant interaction between scene component and emotion ($F_{(2,34)} = 3.60$, MSE = 0.05, $p<.05$, $_p^2 = .18$). Planned contrasts revealed no significant difference between recognition of backgrounds with a neutral or emotional object [$F_{(1,17)} = 0.34$, $p = .57$] but the worse recognition of backgrounds with a negative than positive object did approach significance [$F_{(1,17)} = 4.11$, $p = .06$]. There were no significant differences between recognition of emotional and neutral objects [$F_{(1,17)} = 2.92$, $p = .11$] nor between negative and positive objects [$F_{(1,17)} = 0.11$, $p = .75$].

The possibility of a response bias towards emotional stimuli was checked as for Experiment 6 and no evidence for such a bias was found.

Eye Movement Results

The eye movement recording data was converted into a text file using the iView IDF Converter that is the manufacturer's standard program provided by SensoriMotoric. This file was converted into a format suitable for iLab toolbox using iView Output Utility (Van Heuven, 2008). The iLab toolbox for MatLab (Gitelman, 2002) was used to extract fixations from the data. A dispersion-threshold identification algorithm was used to identify fixations as groups of consecutive points within a particular dispersion. The dispersion threshold was set to include 1.5 of visual angle at 51 pixels with a minimum duration threshold of 100ms (Salvucci & Goldberg, 2000). iView Output Utility was used to identify whether fixations were made on to the object or background of scenes. MS Excel was used to collate trial data and determine participant averages across items for the eye movement measures. Trials with x,y co-ordinates of 0,0 recorded (i.e. blinks or other loss of tracking) for more than 15% of a trial, and less than 1500ms of valid fixations for that trial (75% of trial duration), were defined as containing excessive blinks and excluded from analysis. Data from 3 of the original 21 participants were removed because more than five trials had excessive blinks as defined above.

Repeated measures ANOVAs were used to examine whether the emotion of the object in the scene (negative, neutral, positive) and scene component (object, background) interacted with the different eye movement measures (see Table 4.4). The following ANOVAs were also conducted with the additional factor of object location (central or not central). Location of the object had been manipulated to ensure this was not responsible for the first fixation location. Object location always interacted with scene component but as this factor did not interact with emotion these results are not discussed further.

Table 4.4. Mean average (SE) number of fixations, gaze duration and fixation duration made on object or background scene components for scenes with a neutral background and a negative, neutral or positive object.

Emotion	Object	Background
	No. of Fixations	
Negative	5.45 (0.15)	1.60 (0.14)
Neutral	5.26 (0.19)	1.94 (0.12)
Positive	5.17 (0.20)	1.92 (0.14)
	Total Gaze duration (ms)	
Negative	1421.92 (28.57)	419.29 (26.14)
Neutral	1358.71 (31.46)	486.58 (27.43)
Positive	1327.99 (35.58)	516.30 (30.99)
	Mean Fixation Duration (ms)	
Negative	270.92 (9.64)	290.24 (14.59)
Neutral	274.19 (12.84)	266.39 (11.71)
Positive	272.85 (16.40)	297.72 (14.00)

A 2 (scene component) x 3 (emotion) repeated measures ANOVA analysing the number of fixations for the factors scene component and emotion revealed a significant main effect of scene component ($F_{(1,17)}$ = 316.59, MSE = 326.17, p<.001, η_p^2 = .95) but not of emotion [$F_{(2,34)}$ = 1.06, MSE = 0.05, p = .36, η_p^2 = .06]. There was a significant interaction between scene component and emotion ($F_{(2,34)}$ = 4.57, MSE = 0.98, p<.05, η_p^2 = .21). Planned contrasts revealed no significant difference in the number of fixations made onto an emotional or neutral object [$F_{(1,17)}$ = 0.24, p = .63] but did reveal a significantly greater number of fixations on the object in negative than positive scenes ($F_{(1,17)} = 5.06$, $p < .05$). Planned contrasts also revealed no significant difference in the number of fixations made onto the background of a scene presented with an emotional or neutral object [$F_{(1,17)} = 2.65$, $p = .12$] but did reveal a significantly reduced number of fixations on the background in scenes with a negative than positive object ($F_{(1,17)} = 9.55$, $p < .01$).

The number of fixations were examined further by analysing the number of fixations made on the object as a proportion of the total number of fixations on the scene (fixations on the object/fixations on the object + fixations on the background). The mean average proportions (with standard error in parentheses) for scenes with a negative, neutral or positive object were .77 (.02), .73 (.01) and .73 (.02) respectively. A repeated measures ANOVA on this proportion with the factor emotion revealed a significant main effect ($F_{(2,34)} = 5.82$, MSE = 0.01, $p<.01$, $_{p}^{2} = .26$). Planned contrasts of this factor revealed no significant difference between emotional and neutral items [$F_{(1,17)} = 2.15$, $p = .16$] but did reveal that this proportion was significantly greater for scenes with a negative than positive object ($F_{(1,17)} = 11.68$, $p<.001$).

A 2 (scene component) x 3 (emotion) repeated measures ANOVA analysing the total gaze duration for the factors emotion and scene component revealed a significant main effect of scene component ($F_{(1,17)} = 335.16$, MSE = 2.16^{E7}, $p<.001$, $_{p}^{2} = .95$) but not of emotion [$F_{(2,34)} = 0.10$, MSE = 40.62, $p = .90$, $_{p}^{2}<.01$]. There was a significant interaction between emotion and scene component ($F_{(2,34)} = 6.21$, MSE = 85711.57, $p<.01$, $_{p}^{2} = .27$). Planned contrasts revealed no significant difference between the total gaze duration on an emotional or neutral object in the scene [$F_{(1,17)} = 0.33$, $p = .57$] but did reveal a significantly longer total gaze duration on a negative than positive object in a scene ($F_{(1,17)} = 14.44$, $p < .01$). Planned contrasts also revealed no significant difference between total gaze duration on the background of scenes with an emotional or neutral object [$F_{(1,17)} = 0.50$, $p = .49$] but did reveal significantly lower total gaze duration on the background for scenes with a negative than positive object ($F_{(1,17)} = 17.68$, $p < .01$). (See Figure 4.6).

Total gaze duration was further examined by analysing the total gaze duration on the object as a proportion of the total gaze duration on the scene (total gaze duration on the object/total gaze duration on the object + total gaze duration on the background). The mean average proportions (with standard error in parentheses) for scenes with a negative, neutral or positive object were .77 (.01), .74 (.01) and .72 (.02) respectively. A repeated measures ANOVA on this proportion with the factor emotion revealed a significant main effect ($F_{(2,34)} = 6.47$, MSE = 0.01, $p<.01$, $\eta_p^2 = .28$). Planned contrasts of this factor revealed no significant difference between emotional and neutral items [$F_{(1,17)} = 0.46$, $p = .51$] but did reveal that this proportion was significantly greater for scenes with a negative than positive object ($F_{(1,17)} = 17.37$, $p<.001$).

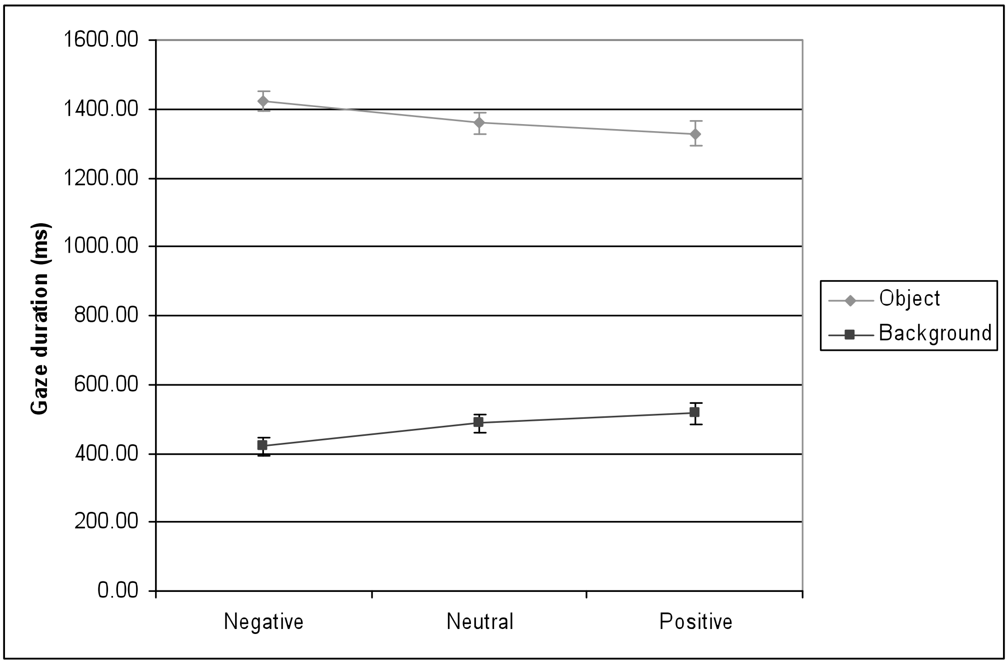


Figure 4.6 Average total gaze duration on background and object scene components across scenes containing a negative, neutral or positive object

A 2 (scene component) x 3 (emotion) repeated measures ANOVA analysing the average fixation duration for the factors emotion and scene component revealed no significant main effects for emotion [$F_{(2,34)} = 2.68$, MSE = 2115.42, $p = .08$, ${}_p^2 = .14$] nor scene component [$F_{(1,17)} = 3.42$, MSE = 3973.57, $p = .08$, ${}_p^2 = .17$] although the interaction between emotion and scene component approached significance [$F_{(2,34)} = 2.89$, MSE = 2749.80, $p = .07$, ${}_p^2 = .15$]. Planned contrasts for the object revealed no significant difference between the average fixation duration for scenes with an emotional or neutral object [$F_{(1,17)} = 0.33$, $p = .58$] or with a negative or positive object [$F_{(1,17)} = 0.04$, $p = .85$]. Planned contrasts for the background revealed significantly shorter average fixation durations on backgrounds of scenes with a neutral than emotional object ($F_{(1,17)} = 7.35$, $p < .05$) but no significant difference between scenes with a negative or positive object [$F_{(1,17)} = 0.42$, $p = .52$].

Section 4.4. Discussion

We again found an enhancement of specific recognition for both positive and negative objects with impairment in backgrounds only for those scenes with a negative object. The findings with general recognition were the same as for Experiment 6; no significant emotional enhancement in general recognition of objects but impairment in memory for backgrounds of scenes with a negative object. The memory results for this experiment demonstrated a similar pattern of results to those from Experiment 6 with a new set of participants. There were some differences in the exact values but the pattern of main effects and interactions were comparable between the two experiments.

We found support for the proposal that attention at encoding is important for the negative emotional enhancement of memory with a greater number of fixations and longer gaze durations on the negative object, than positive object, in scenes with a neutral background. The similar average fixation duration for emotional and neutral objects suggested that rather than negative objects requiring more complex processing, participants chose to explore the negative objects in scenes with more fixations than the neutral or positive objects. If negative objects were more complex to process then we would have expected to find longer average fixation durations for negative than neutral or positive objects, which we did not. The finding of significantly shorter average fixation duration for backgrounds of scenes with a neutral object appears to be an anomaly in the data as we have no explanation for why these backgrounds should be less complex to process and this finding is at odds with the other patterns of results found throughout this series of experiments.

The results from the eye movement recordings are consistent with the central-peripheral trade-off in memory that was found for scenes with a negative, but not positive or neutral, object. Taken together these results suggest attentional effects at the time of encoding may contribute to the enhancement of visual specificity of memory by negative emotion. The lack of any attentional effects with scenes with a positive object suggest that attention effects at encoding are not responsible for the enhancement of visual specificity of memory by positive emotion and that an alternative explanation is required.

The attention narrowing we found for negative stimuli was consistent with previous research examining eye movements which found attention narrowing for negative, in comparison to neutral, stimuli (Christianson et al., 1991). Christianson et al. (1991) found that although attention narrowing was related to a negative emotional enhancement of memory it was not necessary for the memory effect to occur because the emotional enhancement remained even when attention was controlled across neutral and emotional slides, for instance by allowing participants only one fixation on the critical slide. Our findings suggest that the negative enhancement in this experiment is due to the additional fixations on negative objects allowing greater encoding of negative details and ultimately enhancing negative visual memory specificity.

The difference in eye movements between scenes with a positive or negative object, and the similarity in eye movements between scenes with a positive and with a neutral object, provided no evidence that the enhancement of memory for positive objects was due to attention at encoding. This attention narrowing with scenes with negative, but not positive, objects is consistent with one account of emotions' effects on memory (e.g. Kensinger et al., 2007a), which would argue for a broadening effect of positive emotion on attention and a narrowing effect of negative emotion. However, proponents of alternative theories of the effect of emotion on memory (Mather, 2007; Vogt, De Houwer, Koster, Van Damme, & Crombez, 2008) may argue that the lack of attention narrowing with scenes with a positive object may be due to the lower average levels of arousal for positive than negative stimuli, rather than emotional valence. This will be expanded further in the general discussion.

Section 5. Chapter Discussion

We found enhanced visual memory specificity for negative and positive emotional objects when these were presented in isolation and when presented on a contextual background. A central-peripheral trade-off in memory was found for negative objects with an enhancement in memory for the central object at the cost of memory for the peripheral background. This was in contrast to the positive objects where the enhancement in memory for the object was not accompanied by a detriment in memory for the peripheral details. The same pattern of trade-offs was found when assessing specific and general recognition, but these only reached statistical significance with specific recognition, suggesting that these trade-offs are more sensitive to measurement by specific than general recognition. Central-peripheral trade-offs in memory were reflected in the measures of attention. Attention, as measured by eye movements, was narrowed onto negative objects in a scene, but not onto positive or neutral objects. These findings will now be considered in relation to the effect of emotion on memory for details, the involvement of attention at encoding in these memory effects and support for the different accounts of emotions' effects on memory.

The findings with negative emotional stimuli from this study are consistent with previous investigations, including the specific findings reported by Kensinger et al. (2006, 2007a, 2007b). A central-peripheral trade-off with negative emotional stimuli is consistent with previous studies that have investigated this effect using different paradigms (Christianson & Loftus, 1991; Cook et al., 2007; Touryan et al., 2007). The association between this trade-off with negative emotional stimuli and attentional narrowing at encoding is consistent with previous research by Christianson et al. (1991), although these authors demonstrated that the narrowing of attention, as assessed by eye movements, was not necessary for the emotional enhancement in memory to occur. Alternative methodologies have been used to examine the role of attention in the emotional enhancement of memory, one of which examined the attentional capacity required for this enhancement to occur. By dividing attention at the time of study, and at test, between a primary memory task and a secondary task (e.g. random number generation) the enhancing effects of negative emotion have been found to be independent of attention (Clark-Foos & Marsh, 2008; Kern et al., 2005; Talmi et al., 2007). There have been different interpretations of these results. Talmi et al. (2007) argued that the effects of emotion on memory and attention are independent, whereas Clark-Foos & Marsh (2008) argued that there may be a conscious route by which emotion enhances memory through attention and then an unconscious route, independent of attention, which is used when attentional resources are constrained. The relationship between emotion and memory may greatly depend on context (Clark-Foos & Marsh, 2008). Although this study strongly supports the idea of a causal relationship between attention and the emotional enhancement of visual specificity of memory of negative items the fact that we did not independently manipulate attention means that we cannot rule out alternative explanations.

The attentional and memory effects found with positive emotional stimuli from this study are not so easily explained as those with negative emotional stimuli. The enhancement for the details of positive valence objects was not consistent with Kensinger's earlier research which reported no enhancement in memory for details of positive objects (Kensinger et al, 2007a). The effects of negative emotion on memory may be more resilient than those of positive emotion and this may explain why we replicated the effects for negative emotion but had different findings with positive emotion. However, we have now replicated the effect in 3 studies and 2 stimulus sets.

One possibility is that positive stimuli in our experiment differed with regard to the level of approach motivation to those in Kensinger's study. Approach motivation refers to an urge to move toward an object, whereas withdrawal motivation refers to an urge to move away from an object. The level of approach motivation induced by positive emotional stimuli can determine how this emotion influences attention (Gable & Harmon-Jones, 2008) and this could be a route through which different sets of positive stimuli differentially influence memory. Our stimuli were pre-rated on valence and arousal and we have measures on approach motivation from the study phase of the experiment and these clearly show that positive stimuli were not only higher in valence, but also in approach motivation (see meta-analysis Section 5.2, Chapter 5).

The enhancement of memory for details of positive objects provides evidence against arguments that positive emotion leads to more gist-based processing (Bless et al., 1996; Levine & Bluck, 2004; Storbeck & Clore, 2005) as this would not predict an enhancement in memory for details. It also provides evidence against arguments that response bias is responsible for any effects found with positive emotion (e.g. Dougal & Rotello, 2007). There are previous findings with which an enhancement of memory by positive emotion is consistent. These include findings of a general enhancement of memory for positive stimuli (Dewhurst & Parry, 2000; Kern et al., 2005; Talmi et al., 2007) and proponents of the theory that emotional arousal, not valence, is the critical factor in emotions' effects on memory would be likely to predict an enhancement of memory for positive emotionally arousing stimuli (Mather, 2007; Vogt et al., 2008).

To our knowledge there are no studies of central-peripheral trade-offs in recognition memory for positive stimuli. There is, however, one recent article comparing the descriptions of recalled negative and positive emotional autobiographical events. Talarico, Berntsen & Rubin (2009) found that descriptions of negative life events contained a reduced number of peripheral details to those of positive life events. It is not possible to objectively judge the accuracy of recalled memories of personal life events but these findings are consistent with our finding of impaired memory for peripheral details for scenes with a negative object compared to scenes with a positive object. The lack of a central-peripheral trade-off in memory for positive objects is also consistent with research showing that positive emotions lead to a broadening of attention (e.g. Bless et al., 1996). We found no evidence for an effect of positive emotion on the spatial distribution of attention across stimuli. However, our measure of attention was based purely on eye movements and it is possible that people widen their spotlight of attention, and so make cognitive processing easier, without affecting eye movements. An alternative measurement of attention could be a task such as the dot probe task which has been used to demonstrate attentional biases towards and away from emotional stimuli (Mather & Carstensen, 2003). The lack of attentional narrowing with positive stimuli may seem inconsistent with evidence that additional attentional resources at encoding can completely account for a positive emotional enhancement of memory for pictures (Talmi et al., 2007). However, these additional attentional resources may be used to more deeply encode and ruminate on the semantic meaning of the positive emotional stimuli, rather than to affect the spatial distribution of attention. The negative emotional stimuli used in this experiment were of a threatening nature that would have the same meaning to most people (e.g. a knife, a severed arm) whereas, the positive emotional stimuli may have required more interpretation to fully experience the emotion (e.g. a birthday cake). Alternatively, positive emotions may enhance memory through a different route than negative emotions and this may be unrelated to attention. Positive stimuli may be more successfully encoded, and subsequently remembered, as a result of the faster processing of positive than negative information (Unkelbach, Fiedler, Bayer, Stegmuller, & Danner, 2008). In this study participants' attention may have been initially attracted to the positive objects, these could have been more quickly processed and successfully encoded than the negative objects, attention could then have been released from the positive objects, leaving sufficient time to encode the details of the background of the scene and thus avoid any impairment to memory. Note, however, there was no support for this in average fixation durations.

There is no single theory of the effects of emotion on memory which can explain the pattern of results found in this study. Our results are not fully consistent with Kensinger's (2007a) proposal of a valence account of emotion, nor with an alternative theory which proposes that it is the arousing nature of emotional stimuli, rather than their positive or negative valence, which is responsible for these emotional effects (e.g. Mather, 2007; Vogt et al., 2008). Vogt et al. (2008) argued for a predominant effect of emotional arousal, over valence, with slower disengagement of spatial attention for stimuli high in arousal, than low in arousal, regardless of valence. Mather (2007) argued for the importance of emotional arousal and proposed a specific theory to explain how visual memory specificity may be enhanced for arousing objects. Mather (2007) argued that emotionally arousing objects attract attention, which enhances binding of the objects' constituent features and then leads to interference in working memory making it more difficult to maintain other bound representations. This interference leads to an impairment (or no effect) on associations between the objects and other distinct objects or background contextual information, and explains the central-peripheral trade-offs found with emotionally arousing stimuli. According to Vogt et al. (2008) and Mather (2007) we would have expected to find enhancement for details of both positive and negative emotionally arousing central objects and this would lead to a detriment in memory for peripheral details in both cases. The lack of a central-peripheral trade-off in memory for positive emotional stimuli in this experiment could be explained by the lower levels of emotional arousal for the positive than negative stimuli. Due to the nature of stimuli used in this experiment it was not possible to fully match the arousal levels across valence, but it is possible that a central-peripheral trade-off in memory for positive stimuli would appear if it were possible to match arousal levels between negative and positive stimuli.

In conclusion, these results replicated findings of Kensinger and colleagues (2006, 2007a, 2007b) with regards to negative objects using a new stimulus set. However, they call into question the degree to which all such emotional effects can be attributed to overt attentional processes at the time of encoding and also highlight the different processes which may be responsible for the effects of positive emotions on memory. The effects of negative emotion appear to be associated with spatial differences in attention, as measured by eye movements, but the effects of positive emotion do not.

Chapter 5 – Which alternatives to attention focusing could explain emotional enhancement of visual memory specificity?

Section 1. Chapter Introduction

In this chapter we further explore the way in which cognitive processes may be affected by emotion and lead to the enhancement of memory for specific visual details. From chapter 4 we concluded that the focusing of attention onto the source of emotion was an important factor in the process of enhancement of memory by negative emotion but not by positive emotion. However, there have been studies of memory for central and peripheral information which have not supported the attentional narrowing hypothesis (e.g. Libkuman, Nichols-Whitehead, Griffith, & Thomas, 1999; Wessel, van der Kooy, & Merckelbach, 2000).

In this chapter we firstly replicate the finding of attention narrowing from chapter 4 and then investigate whether any other measures of memory performance reveal further insight into the process by which emotion influences memory for specific visual details. We then consider the influence of any carry-over of emotion that might occur between stimuli, the unexpected nature of emotional stimuli and the distinctiveness of emotional stimuli. These are all other potential factors which may in some way be responsible for the emotional enhancement of memory for specific visual details. We will now consider the relevant literature for each of these different possibilities.

Alternative measures of memory: Associative Memory & Implicit Memory

In chapter 4 the measurements of memory performance were restricted to specific and general recognition of objects and backgrounds. Examining alternative measures of memory performance may provide further insight into the processes underlying the emotional enhancement of memory for specific visual details.

Touryan et al. (2007) proposed that emotion may directly influence the associative binding in memory of an item to peripheral information concerning that item. They argued that evidence that stress can disrupt hippocampal processing, a neural structure related to memory formation and binding, provides support for this proposal. Stress can therefore lead to the creation of fragmented memories and this may explain the dissociation between memory for central emotion-eliciting information and peripheral contextual information (Touryan et al., 2007).

Touryan et al., (2007) examined memory for the association between central and peripheral elements of negative and neutral events. Peripheral information was defined as information presented with an event but which was semantically and spatially separate from that event. Participants viewed negative emotional and neutral pictures from the IAPS database (Lang et al., 2001). Peripheral information was a neutral cartoon-like object placed in one corner of the picture. The peripheral information was spatially and conceptually disparate from the central event information to reduce the possibility of pre-existing semantic associations and avoid ambiguous definitions of which elements of the scenes were central or peripheral. The use of spatial and conceptually disparate peripheral objects allowed counterbalancing of presentation of objects with neutral or negative scenes. (Similarly to the experiments reported in our paradigm where the presentation of neutral backgrounds was counterbalanced across different emotional objects). Memory was assessed by free recall of objects and pictures, a mirror-reversal test of pictures to indicate whether participants had a specific memory of the picture and could distinguish the original presentation from a picture flipped horizontally by 180 degrees and lastly a cued association memory test. In the cued association test participants were shown the study picture without the embedded peripheral object and had to identify which of three objects shown below were initially shown with this particular picture. All objects had initially been presented embedded on an IAPS picture. Touryan et al. (2007) found enhanced memory for the negative pictures in the free recall and the mirror-reversal test. This may indicate evidence of enhanced memory for the gist and specific details of negative emotional pictures. There was no emotional influence on free recall of the peripheral object. There was impairment in memory for the association between a peripheral object and picture with negative emotion. This was a novel method of assessing the binding of peripheral and item information and indicated that negative emotion can reduce memory for these associations, beyond the influence of memory for the peripheral information itself. Touryan et al (2007) argued that these findings could result from reduced attention and encoding of the peripheral objects with negative emotion. However, if there is attention narrowing then reduced memory for peripheral objects placed on negative scenes should also be evident and this was not the case. As an alternative they suggest emotion could modulate working memory during retrieval which could then disrupt the associative binding (Touryan et al, 2007). These findings suggest that the examination of associative memory binding may provide further insight into the effects of emotion on memory.

In addition to examining associative memory in this chapter we will also examine a measure of implicit memory. With these type of tasks performance may indicate recognition in cases when participants may not necessarily be able to explicitly access this memory. The involvement of implicit memory mechanisms in emotions' influence on memory is suggested by findings of a role for implicit memories in clinical disorders of emotion, such as depression (Barry, Naus, & Rehm, 2004). The critical link between memory and preference formation has been directly demonstrated by research investigating how preference for a neutral object is influenced by memory for an association between that neutral object and an emotional image (Ghuman & Bar, 2006). When participants explicitly remembered the affective associations they were found to prefer neutral shapes that had been associated with positive images. However, when they did not explicitly remember the affective associations they preferred neutral shapes that had been associated with negative images. Ghuman & Bar (2006) proposed that this preference in the absence of memory for items with a negative association is due to a mechanism which produces an inherent incentive to rapidly assess potential threats in the environment.

In this chapter we will examine the influence of a previously embedded emotional or neutral object on preference for neutral backgrounds. This use of a preference judgement to assess levels of memory was also used in chapter 2 to assess whether exposure to stimuli affected preference judgements in a mere exposure paradigm. In chapter 2 we found that prior exposure to stimuli had no influence on judgements of preference for negative, neutral or positive photographs from the IAPs database (Lang, Bradley, & Cuthbert, 2001). In this case, we concluded that due to the complex nature of these stimuli preference judgements were based on the meaning conveyed by the photographs and therefore this left no opportunity for the influence of prior exposure. In contrast in this chapter we will be examining preference judgements to neutral pictures which formed the background of the stimuli and therefore it should be less likely that preference is influenced by semantic judgements.

Carry-over of emotion across stimuli

One aspect of experimental design which relates to the emotion experienced by participants is the carry-over of emotion across stimuli. It is possible that when presenting emotional stimuli to participants there are effects which continue onwards after presentation of that particular stimulus (McKenna & Sharma, 2004; Waters, Sayette, & Wertz, 2003). One way in which these type of effects have been investigated is by using a variant of the Stroop (1935) task where participants must name the colour in which words are presented. In the emotional Stroop effect, emotional words are presented in different font colours and participants are asked to name the colour whilst ignoring the word. This is often slower for emotional than neutral words (for a review see Williams, Mathews, & MacLeod, 1996).

One factor which has been investigated is the impact of stimuli order on the Stroop effect. Slower responses to certain types of words have been demonstrated in blocked groups of concern-related stimuli but these effects can greatly diminish or disappear with mixed lists of neutral and concern-related stimuli (Waters & Feyerabend, 2000). It has been argued that there may be carry-over effects in the blocked Stroop task where participants ruminate about previous words as they continue to colour-name target items later in the sequence. These carry-over effects in blocks with concern-related words may increase the size of the Stroop effect in blocked versions of the stroop (see Waters et al., 2003). Waters et al (2003) demonstrated carry-over effects in a Stroop task with smokers where the concern-related words were about smoking.

An alternative interpretation of this emotional Stroop effect is that emotional words automatically attract attention, distracting the participant from the colour-naming task and therefore increasing the time required to name the colour of the emotional words, relative to the neutral words. McKenna & Sharma (2004) used a Stroop-like task to investigate the intrusion of emotion on cognitive processing. They investigated a fast interference effect described as interference of emotion with the response within the trial of a threatening stimulus (the theory that emotional words automatically attract attention which is proposed by many authors in this area) and a slow interference effect described as the interference of emotion with stimuli presented after the threatening stimulus. They found evidence for a slow effect which lasted for one subsequent trial, but no evidence for a fast interference effect. They discussed several possible mechanisms which might explain the pattern of disruption found from negative emotional stimuli. McKenna & Sharma (2004) firstly discounted the theory that mood inductions across stimuli may explain the effects, one reason given was that the disruption effects observed lasted for less than one second, whereas mood induction normally takes many seconds to develop. They suggest that the slow effects they found may be interpreted as negative stimuli preventing the disengagement of attention or that interference may result from preparation to respond to a threat which may be demonstrated through interference to a subsequent stimulus.

In the experimental design used here it will not be possible to assess the interference from a slow effect of emotional disruption as an interstimulus interval of no more than 32 milliseconds was found to be necessary (McKenna & Sharma, 2004) for these effects to occur. In the paradigm used there is at least 2 seconds between each stimulus presentation as a result of the fixation crosses shown before and after each stimulus. Increasing the intertrial trial interval has been shown to reduce the interference from negative stimuli and intervals of 1 second were found to produce a disruption of only 11 milliseconds (Sharma & McKenna, 2001). This suggests that any slow effects of interference are unlikely to have any impact on the experimental design here.

It is possible that the fast effects of interference from emotional disruption within a trial may be a contributory factor to the lack of memory for peripheral details of negative emotional stimuli. It has been proposed that these interference effects in the emotional stroop are due to the automatic attention grabbing of emotional stimuli which leads to a reduced response time to the task (e.g. Williams et al, 1997). It is possible that there is automatic grabbing of attention by the negative objects in a scene which then interferes with the processing of the backgrounds of these stimuli, leading to impaired memory for these peripheral details.

Factors unrelated to intrinsic emotion (Distinctiveness and surprise)

It is possible that the influences of emotion on cognition that are demonstrated in experimental paradigms such as those used in this thesis may be due to factors associated with the emotional stimuli that are not elements intrinsic to the experience of emotion. The two factors which we will explore in this chapter are the influence of the unexpected and surprising nature of the emotional stimuli and the relative distinctiveness of the emotional stimuli within the experiment as a whole.

i)Unexpected nature of emotional stimuli

The possibility that the influence of emotional stimuli may be due to their unexpected nature has been explored particularly in studies using a one story slide show. This has often been done by comparing memory for an emotional, neutral and surprising version of an event. Christianson et al. (1991) presented participants with a thematic series of slides with one critical slide in the middle of the series on which memory was tested. This critical slide differed depending on the condition: in the neutral condition this showed a woman riding a bike, in the emotional condition the was woman lying on the ground beside her bike bleeding from a head injury and in the unusual condition the woman was carrying the bicycle on her shoulder. Enhanced memory was found for the emotional version, whilst similar levels of memory were found for the neutral and unusual version of an event.

However, other research has found that novelty may be important in the relationship between emotion and memory. Hope & Wright (2007) investigated the role of visual attention in the weapon focus effect and found that both unusual and threatening objects may capture attention and be better remembered than neutral objects. The weapon focus effect (Loftus et al., 1987) is the phenomenon that criminal incidents involving the presence of a weapon will have a negative impact on eyewitness memory of details such as the perpetrator's facial characteristics and clothes. Hope & Wright (2007) suggested that in order to clarify the components of the weapon focus effect the roles of emotion and novelty must be disentangled. The weapon focus effect is similar to the emotional effects being investigated here with the enhancement of memory for central object details and impairment in memory for peripheral details. These findings described above support the legitimacy of considering the influence of novelty or unusualness of the emotional stimuli on the memory and attentional effects being investigated.

Unusual and novel stimuli could be described as stimuli which surprise the participant when viewed. Neural investigations have found distinct brain regions are activated when expecting unpleasant, compared to pleasant and neutral stimuli and there may be a specific neural network for internal adaptation and preparation processes to enable adequate reactions to expected unpleasant events (Herwig, Abler, Walter, & Erk, 2007). This suggests there may be a differing impact on cognitive processes and behaviour of unpleasant stimuli that are encountered unexpectedly.

The level of surprise experienced can be moderated by warning participants of the nature of the next stimulus to be presented. The presentation of warnings to participants has been shown to affect the ability to perceive complex stimuli. Being given a cue of a specific example of the next stimulus to be seen has improved the perception of complex objects, in a task where participants must discriminate between normal and distorted images of famous faces or places (Puri & Wojciulik, 2008). Although there was no influence on performance when participants were cued with just the general category, rather than a specific example.

ii) Distinctiveness of emotional stimuli

Another possibility is that emotional stimuli may differ to other stimuli in an experiment with regard to their relative distinctiveness. This concept was initially discussed in chapter 2 of this thesis, where emotional stimuli were presented in blocked lists and we argued that some of the difficulty in finding emotional effects in memory may have been due to this element of the experimental design. It has been argued that at least some of the memory effects attributed to emotion were actually due to item distinctiveness (Schmidt, 2002). Dewhurst & Parry (2000) found an emotional enhancement for positive and negative words in the number of correct Remember responses, but not correct Know responses with mixed lists. However, when blocked lists of positive, negative or neutral words were used Dewhurst & Parry (2000) found that the emotional enhancement was eliminated. This was due to higher recognition of neutral items with blocked lists rather than lower recognition of emotional items. Similar elimination of an emotional enhancement has been found by presenting emotional pictures in pure rather than mixed lists (Talmi et al., 2007).

Schmidt & Saari (2007) investigated why distinctiveness of emotional stimuli may lead to this effect. Possibilities considered include the interpretation that distinctive/emotional material receives increased processing relative to common/neutral material; there may be a contrasting memory representation between distinctive and common information or that the distinctiveness of emotional stimuli creates an attention magnet leading to increased attention at encoding. Schmidt & Saari (2007) used the Stroop paradigm and compared memory for taboo emotional words, nontaboo emotional words and neutral words. They concluded that the taboo and nontaboo emotional stroop effect are different phenomena. They found recall of taboo words exceeded memory for neutral words in both mixed-list and between-subjects pure list designs and that good memory for nontaboo emotional words appeared to depend less on increased attention at encoding than for taboo words, and more on item distinctiveness.

Therefore, in this chapter we will consider how distinctiveness of emotional stimuli might relate to the effects found in this thesis by examining the influence of blocked or pure lists of emotional stimuli on memory for the details of both central and peripheral details of the stimuli. Firstly, we return to associative and implicit memory which are examined in the first experiment of this chapter.

Section 2. Experiment 8:

Section 2.1. Introduction

The aim of this experiment is to replicate the findings of Experiment 7 with a new set of participants and investigate if there are reasons, other than attention narrowing, which may explain the lack of a central-peripheral trade off in memory for scenes with a positive object. Specifically, whether there is enhanced memory for the association between the object and background with positive emotion or whether an implicit memory of which object is associated with which background is formed.

We predict that the pattern of memory results for specific and general recognition and the eye movement results will replicate the findings of Experiment 7. That is to say emotional enhancement of specific and general recognition for negative and positive stimuli, a central-peripheral trade-off in memory for negative stimuli and attention narrowing onto the object in scenes with a negative object. We predict that the positive emotional enhancement of memory will to some extent be due to greater memory for the association between the object and the background which will be revealed in the level of memory for that association and also in some degree of implicit memory reflected in a greater preference for backgrounds which have been previously presented with positive objects.

Section 2.2. Method

Design

A within-participants mixed list design was used with scenes of a neutral background and either a negative, neutral or positive object. The aim of the experiment was to examine participants' eye movements at the time of encoding and investigate whether a range of measures of memory performance could provide insights into factors other than attention which could explain the emotional enhancement of memory. The design of the associative memory test is similar to that used by Touryan et al (2007).

Participants

22 participant took part in this experiment, data from 4 were excluded due to problems with the calibration of the eye tracker. Data from 18 participants (13 female) were included in this experiment. All were native

English speaking University of Nottingham students (mean age = 20.9 years, SD = 2.5). Informed consent was obtained from all participants. Participants were given an inconvenience allowance of £5 for their voluntary participation.

Material

The same materials were used as in Experiment 7.

Procedure

Study

The same procedure was used as for Experiment 7. (For results of study phase ratings see meta-analysis in Section 5.2, Chapter 5).

Test

The procedure for the test phase was identical to that for Experiment 7, with the addition of two memory tests which were completed after the Same/Similar/New test. Participants were unaware that they would be given additional memory tests. After the Same/ Similar / New test participants were first tested for their preference for the neutral backgrounds which had been presented during the experiment. The backgrounds were presented to the participants one at a time and in a random order, without the object. Participants rated how much they liked the background on an 11 point Likert type scale using labeled computer keys to respond. An 11 point scale was used as this provided the same range of possible responses as the scale used to rate the backgrounds for emotion in Experiment 6. The ratings ranged from 1 (*not at all*) to 11 (*like it very much*). Next participants' memory for the associations between the 48 objects and backgrounds that were presented as composite images during the study phase was tested. Participants were presented with a background they had seen in the study phase with three objects presented beneath. Each object had been shown previously to participants during the study phase. In each triad of objects there was one negative, one neutral and one positive object. Participants had to indicate by key press which object had been presented with that background in the study phase of the experiment. Each triad of objects was presented to participants three times during this memory test. Participants were shown all 48 backgrounds that they had seen previously in the study phase.

At the debrief 15 participants confirmed that the memory test was a surprise, 3 participants were not sure. Overall memory performance was comparable between these two groups.

Section 2.3. Results

Memory Data

Analysis of the memory data from Experiment 8 was carried out in the same way as for experiment 7 (see Table 5.1). (For statistical analysis of the responses given to different items see Appendix 5.1.) The influence of emotion on specific and general recognition was examined by conducting separate repeated measures ANOVAs with the factors scene component (object, background) and emotion (negative, neutral, positive) (See Figure 5.1).

Table 5.1: Mean proportion of responses (SE) for objects and backgrounds as a function of item type (same, similar or new) and emotion type (negative, neutral or positive)

	Item type:					
	Same	Similar	New	Same	Similar	New
Response type:	Negative objects			Background (Negative)		
'Same'	.78 (.04)	.34 (.04)	.01 (.01)	.33 (.05)	.13 (02)	.03 (.01)
'Similar'	.15 (.03)	.50 (.05)	.17 (.04)	.26 (.04)	.38 (.06)	.18 (.03)
'New'	.07 (.03)	.16 (.04)	.81 (.04)	.41 (.05)	.50 (.06)	.79 (.04)
	Neutral objects			Background (Neutral)		
'Same'	.72 (.06)	.18 (.04)	.01 (.01)	.46 (.07)	.16 (.03)	.03 (.01)
'Similar'	.16 (.03)	.50 (.04)	.13 (.04)	.17 (.04)	.31 (.05)	.18 (.03)
'New'	.13 (.03)	.32 (.05)	.87 (.04)	.37 (.05)	.53 (.05)	.79 (.04)
	Positive objects			Background (Positive)		
'Same'	.83 (.04)	.25 (.05)	.02 (.01)	.43 (.06)	.23 (.04)	.03 (.01)
'Similar'	.10 (.03)	.53 (.05)	.09 (.02)	.24 (.04)	.33 (.05)	.18 (.03)
'New'	.06 (.03)	.22 (.04)	.89 (.03)	.33 (.06)	.44 (.06)	.79 (.04)

NB. Data for new backgrounds is averaged across emotion as it was not possible for any of these backgrounds to be associated with an emotion.

For specific recognition there was a significant main effect of scene component ($F_{(1,17)}$ = 42.88, MSe = 3.75, p < .001, *partial eta*^{2} = .72) with greater specific recognition for the objects than backgrounds. There was no significant main effect of emotion [$F_{(2,34)}$ = 2.56, MSe = 0.05, p = .09, *partial eta*^{2} = .13]. There was a significant interaction between emotion and scene component ($F_{(2,34)}$ = 5.45, MSe = 0.10, p < .01, *partial eta*^{2} = .24). Planned contrasts revealed that there was no significant difference between specific recognition of backgrounds initially presented with an emotional or neutral object [$F_{(1,17)}$ = 2.32, p = .15] but the worse recognition of backgrounds presented with a negative than positive object did approach significance [$F_{(1,17)}$ = 4.38, p = .05]. Planned contrasts revealed significantly greater recognition for emotional than neutral objects ($F_{(1,17)}$ = 6.47, p < .05) and that the greater recognition of positive than negative objects approached significance [$F_{(1,17)}$ = 3.77, p = .07].

For general recognition there was a significant main effect of scene component ($F_{(1,17)}$ = 33.66, MSe = 2.19, p < .001, *partial eta*^{2} = .66) with greater general recognition for the objects than backgrounds. There was no significant main effect of emotion, although it did approach significance [$F_{(2,34)}$ = 2.69, MSe = 0.03, p = .08, *partial eta*^{2} = .14], and no significant interaction between emotion and scene component [$F_{(2,34)}$ = 1.91, MSe = 0.02, p = .17, *partial eta*^{2} = .10]. Planned contrasts revealed that although there was no significant difference between general recognition of backgrounds with a neutral or emotional object [$F_{(1,17)}$ = 0.01, p = .93] there was significantly reduced recognition for backgrounds with a negative than positive object ($F_{(1,17)}$ = 5.13, p < .05). Planned contrasts revealed the greater general recognition of emotional than neutral objects did approach significance [$F_{(1,17)}$ = 3.55, p = .08] but the difference between positive and negative objects was not significant [$F_{(1,17)}$ = 0.19, p = .67].

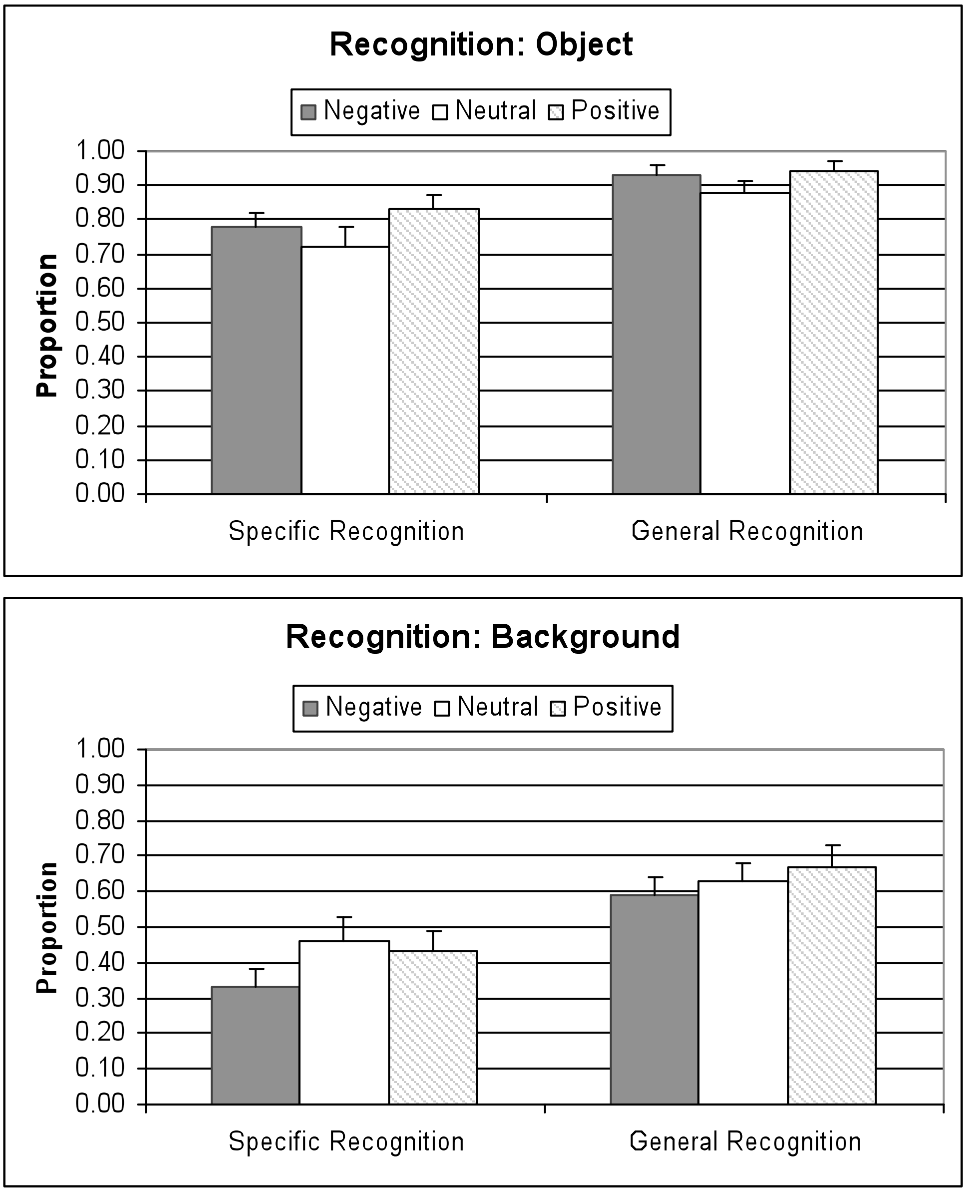


Figure 5.1: Specific and General Recognition to Negative, Neutral or Positive objects presented with Neutral Backgrounds and Neutral Backgrounds presented with Negative, Neutral or Positive objects

Preference for Backgrounds

A repeated measures ANOVA with the factor emotion (negative, positive, neutral) found no significant main effect of emotion [$F_{(2,34)} = 1.35$, MSe = 0.41, $p = .27$, *partial eta*$^2 = .07$].

Associative Memory

In the associative memory test participants were shown one neutral background and had to choose between a negative, neutral and positive object to indicate which object had been presented with the background as a composite image in the study phase of the experiment. It is possible that participants were biased into choosing an object of a particular type even though they did not have memory for that object; i.e. a response bias. To further examine this possibility we analysed the results for the associate memory test by calculating the number of times that participants chose the correct object as a proportion of the number of times they chose that type of object throughout the associate memory test. i.e. the number of times participants correctly chose the negative object as a proportion of the total number of times they chose the negative object during the memory test. This provided a measure of correct associative memory which had been corrected for bias to respond with a particular emotion regardless of memory and was analysed by conducting a repeated measures ANOVA with the factor of emotion. The main effect of emotion was not significant [$F_{(2,34)} = 0.46$, MSe < 0.01, $p = .64$, *partial* $eta^2 = .03$]. Planned contrasts found no significant difference between responses to emotional or neutral items [$F_{(1,17)} = 0.68$, $p = .42$], nor between responses to positive or negative items [$F_{(1,17)} < 0.01$, $p = .95$].

Results of Eye Movement Analysis

Data were extracted and analysed in exactly the same way as for experiment 7 (see table 5.2). Repeated measures ANOVAs were used to examine whether the emotion of the object in the scene (negative, neutral, positive) and scene component (object, background) interacted with the different eye movement measures. The following ANOVAs were also conducted with the additional factor of object location (central or not central). Object location always interacted with scene component but as this factor did not interact with emotion these results are not discussed further. Additionally for average fixation duration there was a main effect of object location.

Repeated measures ANOVA analysing the number of fixations for the factors emotion and scene component found no significant main effect for emotion [$F_{(2,34)} = 0.49$, MSe = 0.02, $p = .62$, *partial eta*^{2} = .03], but did find a significant main effect for scene component ($F_{(1,17)} = 533.33$, MSe = 480.28, $p < .001$, *partial eta*^{2} = .97), with a significantly greater number of fixations on the object than the background. There was a significant interaction between emotion and scene component ($F_{(2,34)} = 7.16$, MSe = 3.02, $p < .01$, *partial eta*^{2} = .30). Planned contrasts revealed a significantly greater number of fixations were made on emotional than neutral objects ($F_{(1,17)} = 10.19$, $p < .01$), there was a greater number of fixations on negative than positive objects which approached statistical significance [$F_{(1,17)} = 4.26$, $p = .06$]. There was a significantly greater number of fixations on backgrounds with neutral than emotional objects ($F_{(1,17)} = 7.67$, $p < .05$), and a significantly greater number of fixations on backgrounds with a positive than negative object ($F_{(1,17)} = 4.77$, $p < .05$).

The number of fixations made were also analysed by examining the number of fixations made on the object as a proportion of the total number of fixations on the scene (fixations on the object/fixations on the object + fixations on the background). There was an average proportion (S.E.) of .81 (.02) on scenes with a negative object, .74 (.02) on scenes with a neutral object and .76 (.02) on scenes with a positive object. A repeated measures ANOVA on this proportion with the factor emotion revealed a significant main effect ($F_{(2,34)} = 6.57$, MSe = 0.02, $p < .01$, *partial eta*^{2} = .28). Planned contrasts revealed this proportion was significantly greater for scenes with an emotional than neutral object ($F_{(1,17)} = 8.86$, $p < .01$) and significantly greater for scenes with a negative than positive object ($F_{(1,17)} = 5.01$, $p < .05$).

Table 5.2: Eye measurements on object or background scene components for scenes with a neutral background and negative, neutral or positive object

Emotion	Object	Background
	No. of Fixations	
Negative	6.40 (0.20)	1.56 (0.14)
Neutral	5.81 (0.20)	2.12 (0.16)
Positive	6.07 (0.20)	1.96 (0.14)
	Total gaze duration (ms)	
Negative	1512.36 (44.83)	372.71 (28.21)
Neutral	1371.46 (48.67)	494.24 (33.00)
Positive	1414.86 (41.74)	458.68 (35.22)
	Mean fixation Duration (ms)	
Negative	245.95 (11.91)	259.74 (12.67)
Neutral	247.35 (11.92)	260.29 (16.55)
Positive	244.87 (11.36)	248.12 (10.01)

Repeated measures ANOVA analysing the total gaze duration for the factors emotion and scene component found no significant main effect for emotion [$F_{(2,34)} = 0.83$, MSe = 854.79, $p = .44$, *partial eta*^{2} = .05] but there was a significant main effect for scene component ($F_{(1,17)} = 346.16$, MSe = 2.65^{E7}, $p < .001$, *partial eta*^{2} = .95) with significantly longer total gaze durations on the object than the background of the scene. There was also a significant interaction between emotion and scene component ($F_{(2,34)} = 5.76$, MSe = 163149.41, $p < .01$, *partial eta*^{2} = .25). Planned contrasts revealed significantly longer total gaze duration on the emotional than neutral objects ($F_{(1,17)} = 9.61$, $p < .01$), with the longer total gaze duration on negative than positive objects approaching significance [$F_{(1,17)} = 4.30$, $p = .05$]. For the backgrounds there was significantly lower total gaze duration on the backgrounds that had been presented with emotional than neutral objects ($F_{(1,17)} = 6.82$, $p < .05$) with the lower total gaze duration on backgrounds of scenes with positive than negative objects approaching significance ($F_{(1,17)} = 3.83$, $p = .07$). (See Figure 5.2).

The total gaze duration was also analysed by examining the total gaze duration on the object as a proportion of the total gaze duration on the entire scene (total gaze duration on the object/total gaze duration on the object + gaze duration on the background). There was an average proportion (S.E.) of .80 (.02) on scenes with a negative object, .73 (.02) on scenes with a neutral object and .76 (.02) on scenes with a positive object. A repeated measures ANOVA on this proportion with the factor emotion revealed a significant main effect ($F_{(2,34)} = 5.37$, MSe = 0.02, $p < .01$, *partial eta*^{2} = .24). Planned contrasts revealed a significant difference between this proportion for scenes with an emotional and neutral object ($F_{(1,17)} = 8.45$, $p < .01$) but the difference between scenes with a negative and positive object only approached significance [$F_{(1,17)} = 3.64$, $p = .07$].

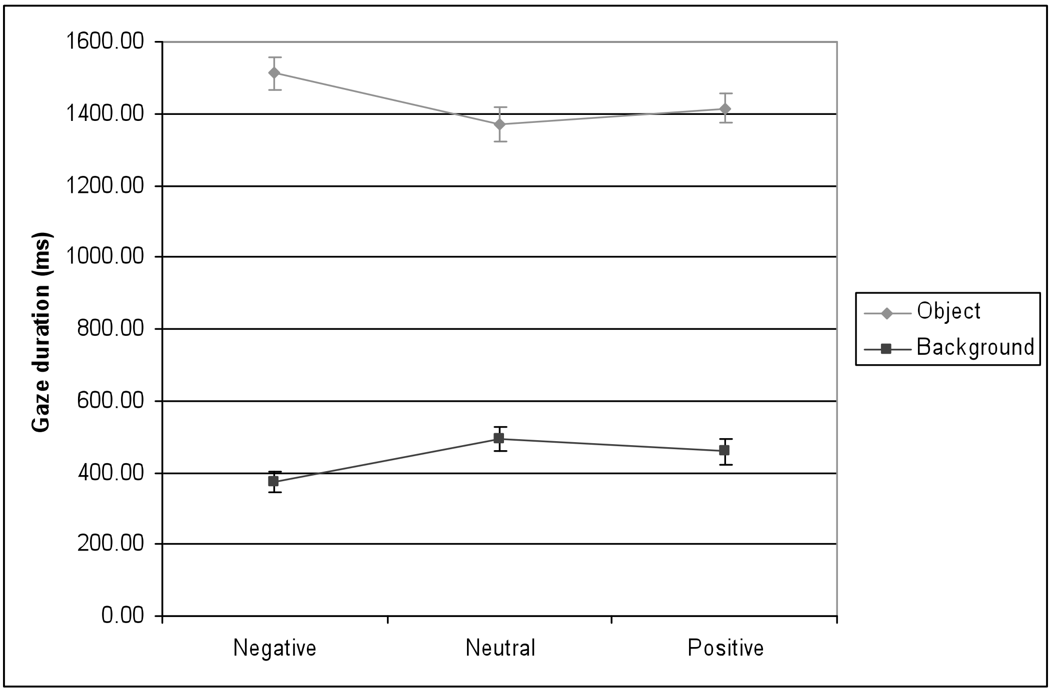


Figure 5.2. Average total gaze duration on object and background scene components of scenes with a negative, neutral or positive object

Repeated measures ANOVA analysing the average fixation duration for the factors emotion and scene component found no significant effect for emotion [$F_{(2,34)}$ = 0.814, MSe = 569.42, p = .45, *partial eta*^{2} = .05] but did find a significant effect for scene component ($F_{(1,17)}$ = 5.51, MSe = 2695.02, p < .05, *partial eta*^{2} = .25]. There was no significant interaction between emotion and scene component [$F_{(2,34)}$ = 0.46, MSe = 309.03, p = .63, *partial eta*^{2} = .03]. Planned contrasts found no significant difference between average fixation duration on neutral and emotional objects [$F_{(1,17)}$ = 0.46, p = .51], nor between positive and negative objects [$F_{(1,17)}$ = 0.04, p = .85]. Planned contrasts also found no significant difference between average fixation duration on backgrounds of scenes with a neutral or emotional object [$F_{(1,17)}$ = 0.39, p =

.54], nor on backgrounds of scenes with a negative or positive object [$F_{(1,17)}$ = 1.10, p = .31].

Section 2.4. Discussion

These results very closely follow those from Experiment 7. We found an emotional enhancement for the specific recognition of positive and negative objects, with the same pattern for general recognition although this effect only approached statistical significance here.

We found a central-peripheral trade off in memory with impairment in the general recognition for backgrounds that had initially been presented with negative objects, with this impairment in specific recognition approaching statistical significance.

The eye movement measurements of number of fixations and gaze duration showed evidence of attention narrowing at encoding onto the emotional objects. Participants looked for longer and with more fixations at negative than positive or neutral objects, and looked for a shorter time at backgrounds on which there was a negative object. There were no emotional differences with average fixation duration, suggesting that the differences in the other eye movement measurements were not due to the emotional stimuli being inherently more complex.

The above results are consistent with predictions we made that the emotional enhancement of specific and general recognition of objects, central-peripheral trade-off with negative emotion and accompanying attentional narrowing would replicate the pattern of results found in Experiment 7. This demonstrates the reliability of these effects and gives a strong foundation of consistent experimental findings from which to manipulate different factors of the procedure and explore the processes underlying this effect.

We found no significant emotional influence on memory for the association between an object and the background on which it was initially presented. These findings are not consistent with our prediction that there would be greater memory for this association with positive emotion. We had predicted that there would be a greater link in memory between backgrounds and objects when that object was positive, but we found no evidence of this for positive or negative emotions.

These findings are not consistent with those of Touryan et al. (2007) who found reduced memory of the association between a peripheral object and the photograph on which it had been presented when the photograph had been negative, rather than neutral. There were differences in the paradigm of Touryan et al. and that used here which may explain the differences. Touryan et al. (2007) were testing memory for the association between an object that was both spatially and conceptually disparate from the central image (photograph) whereas we were testing memory for the association between peripheral background of the scene and the central object and therefore the peripheral object was only spatially disparate, not also conceptually disparate. Additionally, the task here may have been easier than that in Touryan et al. (2007) and greater levels of performance may have masked any emotional differences. Performance was at approximately 60% in Touryan et al (2007) compared to approximately 80% in this experiment.

There was no evidence that memory for an emotional object affected any implicit memory for the background as measured by level of preference to the background when presented later in isolation. All backgrounds were emotionally neutral and therefore we would have expected any evidence for implicit memory to be manifested by an increased preference for backgrounds that had initially been presented with a positive object and a decreased preference for those presented with a negative object. These findings are not consistent with our prediction that there would be some implicit memory of the association between objects and backgrounds. These findings are not consistent with theories proposing a role for implicit memory mechanisms in the relationship between emotion and memory (e.g. Barry et al., 2004), however, it may be that the relationship between preference, memory and emotion is more complex and has been masked by additional factors. The lack of emotional influence on preference judgements found in this experiment is similar to the findings of preference in Chapter 2 where there was no influence of prior exposure on preference for emotional or neutral stimuli. It is possible that it is difficult to uncover influences on preference that are independent of any prior knowledge and opinions of the participants and that the types of stimuli used in this thesis are too complex to uncover such differences.

The findings of association memory and preference for the backgrounds are not consistent with the predictions which we made and suggest that these factors are not related to the visual memory specificity found with negative and positive emotion. This experiment found no evidence for two possible explanations of enhanced visual memory specificity by positive emotion, namely increased associative memory and some form of implicit memory. Therefore, Experiment 9 was conducted to examine the possibility that distinctiveness of positive emotional stimuli may explain the visual memory specificity enhancement.

Section 3. Experiment 9

Section 3.1. Introduction

Experiment 8 did not support associative binding or implicit memory as underlying the observed memory differences. Therefore, we will now consider whether the distinctiveness of emotional stimuli may contribute towards these effects. As discussed in the introduction to this chapter, distinctiveness of emotional stimuli has been argued to play an important role in the emotional enhancement of memory (e.g. Talmi et al., 2007). This possibility is explored in this experiment by blocking the presentation of stimuli into lists containing stimuli of one type of emotion.

In line with previous research in this area we predict that the presentation of stimuli in blocks of emotion will eradicate the emotional enhancement of both specific and general recognition. We also predict that the attention focusing seen onto negative objects in a scene in Experiment 7 will be eradicated.

Section 3.2. Method

Design

A within-participants blocked list design was used with scenes of a neutral background and a negative, neutral or positive object to examine the role of distinctiveness in the emotional enhancement of visual memory specificity. Eye movement measurements will also be recorded to examine the influence of distinctiveness on the distribution of visual attention whilst participants are encoding the scenes.

Participants

18 participants (12 female) took part in this experiment. All were native English speaking University of Nottingham students (mean age = 19.39 years, SD = 1.38). Informed consent was obtained from all participants. Participants received an inconvenience allowance of £3 for their voluntary participation.

Materials

The same materials were used as in experiment 7.

Procedure

Study

All aspects of the experiment were identical to those of experiment 7, apart from the following adaptations to allow for the presentation of stimuli in blocked lists. After participants had been shown the example stimuli and eye calibration was complete participants were presented with additional instructions. There was an interval of 20 seconds before the first block of stimuli were shown, during this time participants were told they would be shown 16 pictures which were mostly unpleasant (if the first block was negative). In order to increase the anticipation participants might feel about the upcoming negative block of stimuli it was emphasized that if they feel upset by these pictures they are free to withdraw from the experiment at any stage. After the 20 second interval participants were presented with 16 experimental stimuli of neutral backgrounds with a negative object for 2 seconds each. A central fixation was shown for 1 second before and after each stimulus. After each picture participants completed the encoding task indicating whether they would like to move closer or further away from the scene. The second block of stimuli were then shown, preceded by a 20 second interval with warning of the emotion of pictures to be shown, as before. For the positive block of stimuli participants were told the pictures would be mostly pleasant. The third block of stimuli was then shown. For the neutral block of stimuli participants were told the pictures would be mostly neither pleasant nor unpleasant.

The version of each scene that was presented at study was counterbalanced in the same way as for Experiment 7. The order of blocks of stimuli was counterbalanced across participants. (For results of study phase ratings see meta-analysis in Section 5.2, Chapter 5).

Test

This was conducted in exactly the same way as Experiment 7.

Section 3.3. Results

Results of Memory Data

Analysis of the memory data from Experiment 9 was carried out in the same way as for experiments 6, 7 and 8 (See Table 5.3). (For statistical analysis of the responses given to different items see Appendix 5.1.)

Table 5.3: Mean responses (SE) for objects and backgrounds as a function of item type (same, similar or new) and emotion type (negative, neutral or positive)

	Item type:					
	Same	Similar	New	Same	Similar	New
Response type:	Negative objects			Background (Negative)		
'Same'	.86 (.05)	.24 (.05)	.01 (.01)	.42 (.05)	.20 (.05)	.03 (.01)
'Similar'	.10 (.04)	.66 (.06)	.17 (.04)	.21 (.03)	.26 (.03)	.16 (.02)
'New'	.04 (.02)	.10 (.04)	.81 (.05)	.38 (.05)	.53 (.06)	.81 (.02)
	Neutral objects			Background (Neutral)		
'Same'	.68 (.06)	.23 (.05)	.03 (.02)	.48 (.07)	.21 (.04)	.03 (.01)
'Similar'	.19 (.05)	.52 (.05)	.08 (.03)	.24 (.04)	.36 (.04)	.16 (.02)
'New'	.13 (.03)	.25 (.03)	.89 (.05)	.28 (.05)	.43 (.05)	.81 (.02)
	Positive objects			Background (Positive)		
'Same'	.79 (.05)	.31 (.05)	.02 (.02)	.51 (.08)	.26 (.05)	.03 (.01)
'Similar'	.17 (.05)	.56 (.06)	.09 (.03)	.18 (.04)	.28 (.06)	.16 (.02)
'New'	.03 (.02)	.13 (.02)	.89 (.03)	.31 (.08)	.46 (.07)	.81 (.02)

NB. Data for new backgrounds is averaged across emotion as it was not possible for any of these backgrounds to be associated with an emotion.

The influence of emotion on the two measures of memory performance was examined by conducting separate 2 x 3 repeated measures ANOVAs with the factors scene component (background, object) and emotion (negative, neutral, positive) on specific and general recognition. For specific recognition there was a significant main effect of scene component ($F_{(1,17)}$ = 42.16, MSe =

2.56, $p < .001$, *partial eta*^{2} = .71) with greater specific recognition for the objects than backgrounds. There was no significant main effect of emotion [$F_{(2,34)} = 1.18$, MSe = 0.05, $p = .32$, *partial eta*^{2} = .07]. There was a significant interaction between emotion and scene component ($F_{(2,34)} = 4.89$, MSe = 0.14, $p < .05$, *partial eta*^{2} = .22). Planned contrasts revealed significantly greater specific recognition for emotional than neutral objects ($F_{(1,17)} = 7.44$, $p < .05$) but no significant difference between negative and positive objects [$F_{(1,17)} =$ 2.91, $p = .11$]. Planned contrasts revealed no significant difference between specific recognition of backgrounds which were initially presented with emotional or neutral objects [$F_{(1,17)} = .04$, $p = .84$] nor negative or positive objects [$F_{(1,17)} = 1.87$, $p = .19$]. (See Figure 5.3).

For general recognition there was a significant main effect of scene component ($F_{(1,17)} = 28.70$, MSe = 1.72, $p < .001$, *partial eta*^{2} = .63) with greater general recognition for the objects than backgrounds. There was no significant main effect of emotion [$F_{(2,34)} = 0.56$, MSe = 0.02, $p = .58$, *partial eta*^{2} = .03]. There was a significant interaction between emotion and scene component ($F_{(2,34)} = 4.26$, MSe = 0.08, $p < .05$, *partial eta*^{2} = .20). Planned contrasts revealed significantly greater general recognition for emotional than neutral objects ($F_{(1,17)} = 7.17$, $p < .05$) but no significant difference between negative and positive objects [$F_{(1,17)} = 0.11$, $p = .75$]. Planned contrasts revealed no significant difference between general recognition for backgrounds which were initially presented with emotional or neutral objects [$F_{(1,17)} = 2.25$, $p = .15$] nor negative or positive objects [$F_{(1,17)} = .84$, $p = .37$].

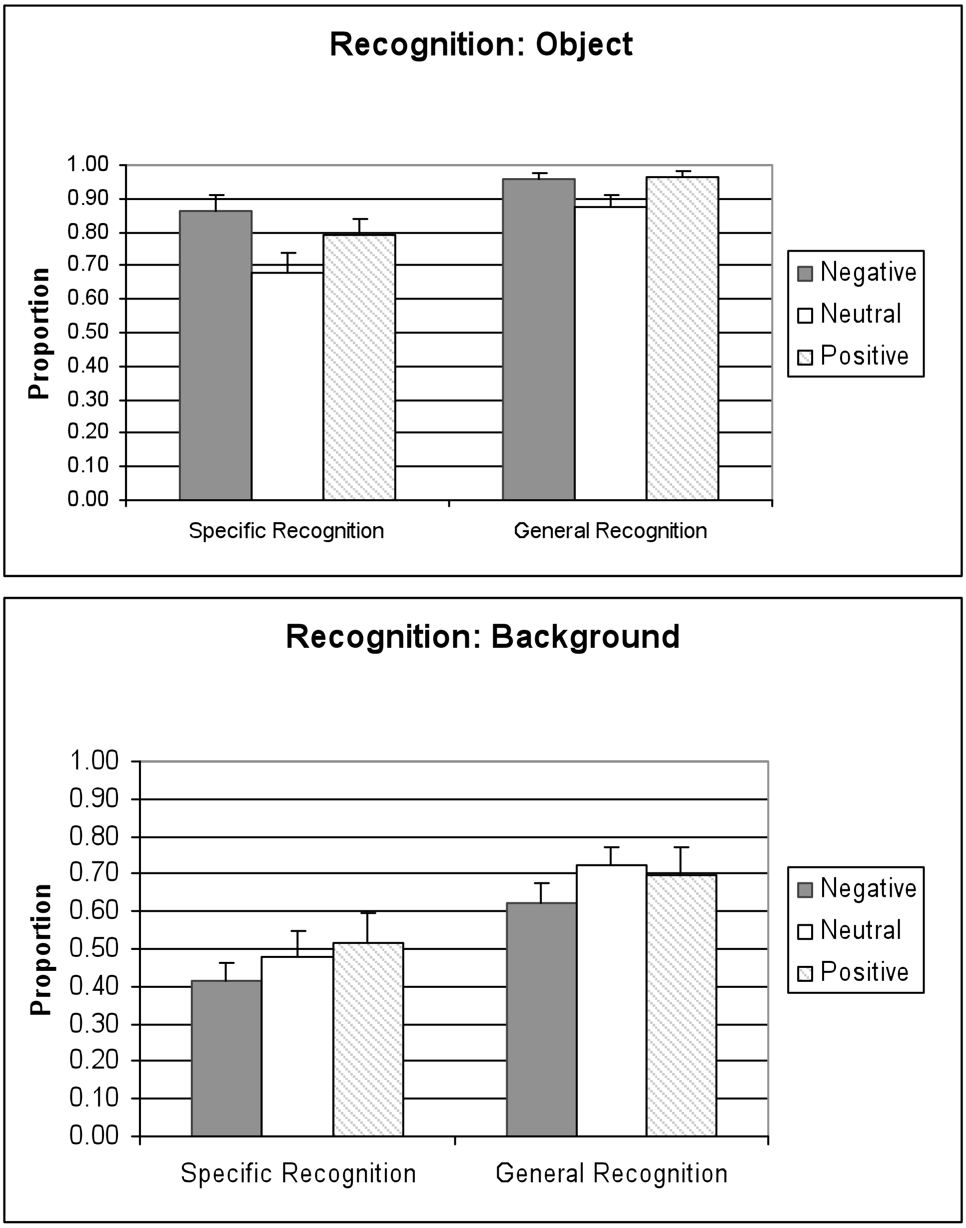


Figure 5.3. Specific and general recognition to negative, neutral or positive objects presented with neutral backgrounds and neutral backgrounds presented with negative, neutral or positive objects

Results of Eye Movement Analysis

The eye movements were extracted from the data and analysed in exactly the same way as described for Experiment 7 and 8. Repeated measure ANOVAs were used to examine whether the emotion of the object in the scene (negative, neutral, positive) and scene component (object, background) interacted with the different eye movement measures (see Table 5.4. The following ANOVAs were also conducted with the additional factor of object location (central or not). Location of the object had been manipulated to ensure this was not responsible for the first fixation location. Object location always interacted with scene component but as this factor did not interact with emotion these results are not discussed further here.

Table 5.4. Eye measurements on object or background scene components for stimuli of negative, neutral or positive emotions

Emotion	Object	Background
	No. of Fixations	
Negative	3.28 (0.22)	3.73 (0.26)
Neutral	3.30 (0.20)	3.81 (0.16)
Positive	3.22 (0.17)	3.79 (0.21)
	Total gaze duration (ms)	
Negative	859.17 (56.75)	952.30 (48.86)
Neutral	847.87 (32.97)	961.82 (39.87)
Positive	837.58 (42.87)	969.58 (39.20)
	Mean Fixation Duration (ms)	
Negative	277.13 (13.37)	271.84 (12.27)
Neutral	272.55 (12.83)	268.88 (15.08)
Positive	275.68 (14.79)	266.73 (10.32)

The number of fixations made onto a scene were analysed by conducting a 3 (emotion) x 3 (scene component) repeated measures ANOVA which found a significant main effect of scene component ($F_{(1,17)}$ = 6.18, MSe = 6.97, p < .05, *partial eta*^{2} = .27), with a significantly greater number of fixations on the background than the object. The main effect of emotion was not significant [$F_{(2,34)}$ = 0.57, MSe = 0.03, p = .57, *partial eta*^{2} = .03] and nor was the interaction between emotion and scene component [$F_{(2,34)}$ = 0.03, MSe = 0.03, p = .97, *partial eta*^{2} < .01].

The number of fixations made were further analysed by examining the number of fixations made on the object as a proportion of the total number of fixations on the scene (fixations on the object/fixations on the object + fixations on the background). There was an average proportion (S.E.) of .47 (.03) on scenes with a negative object, .46 (.02) on scenes with a neutral object and .46 (.02) on scenes with a positive object. A repeated measures ANOVA on this proportion with the factor emotion revealed no significant main effect [$F_{(2,34)}$ = 0.05, MSe < 0.01, p = .95, *partial eta*^{2} < .01]. Planned contrasts revealed no significant differences between this proportion between scenes with an emotional or neutral object [$F_{(1,17)}$ = 0.02, p = .88], nor between scenes with a negative or positive object [$F_{(1,17)}$ = 0.10, p = .75].

The total gaze duration was examined by conducting a 3 (emotion) x 2 (scene component) repeated measures ANOVA for the factors emotion and scene component which found no significant main effect for emotion [$F_{(2,34)}$ = 0.06, MSe = 42.20, p = .94, *partial eta*^{2} < .01]. The main effect for scene component did approach significance [$F_{(1,17)}$ = 4.35, MSe = 344932.52, p = .05, *partial eta*^{2} = .22], with longer total gaze duration on the background than object in a scene. There was no significant interaction between emotion and scene component [$F_{(2,34)} = 0.06$, MSe = 3405.46, $p = .94$, *partial eta*$^2 < .01$]. (See Figure 5.4).

The total gaze duration was further analysed by examining the gaze duration on the object as a proportion of the total gaze duration on the scene (total gaze duration on the object/ total gaze duration on the object + total gaze duration on the background). There was an average proportion (S.E.) of .47 (.03) on scenes with a negative object, .47 (.02) on scenes with a neutral object and .46 (.02) on scenes with a positive object. A repeated measures ANOVA on this proportion with the factor emotion revealed no significant main effect [$F_{(2,34)} = 0.05$, MSe < 0.01, $p = .96$, *partial eta*$^2 < .01$]. Planned contrasts revealed no significant differences between this proportion between scenes with an emotional or neutral object [$F_{(1,17)} = 0.01$, $p = .93$], nor between scenes with a negative or positive object [$F_{(1,17)} = 0.11$, $p = .75$].

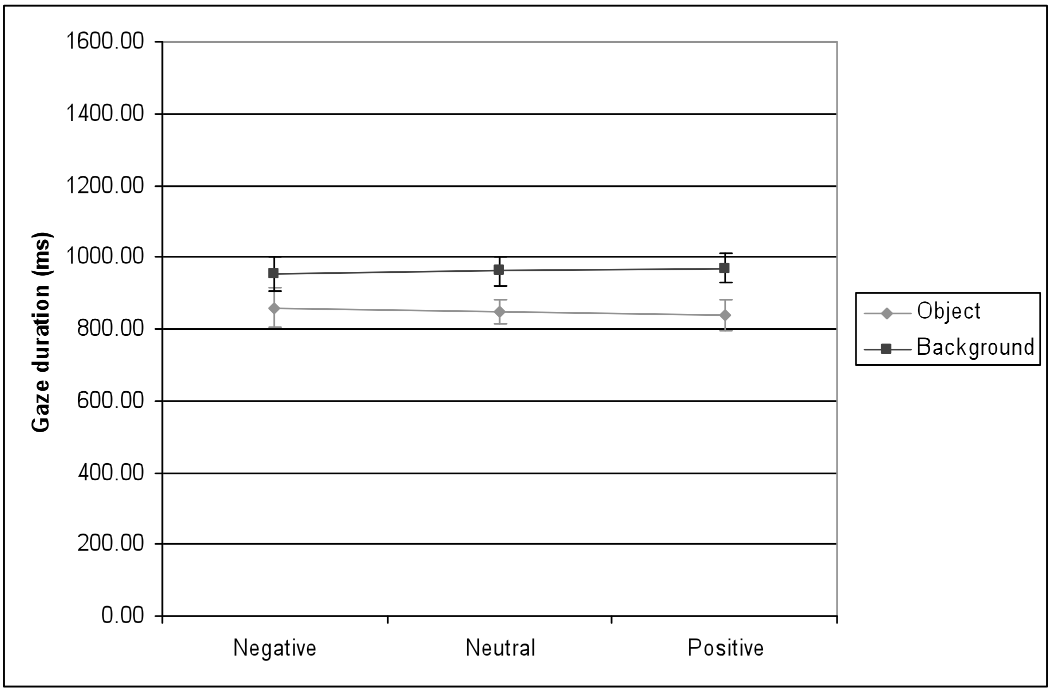


Figure 5.4. Average gaze duration on object and background scene components for scenes with a negative, neutral or positive object

The average fixation duration was examined by conducting a 3 (emotion) x 3 (scene component) repeated measures ANOVA for the factors emotion and scene component. The main effect of emotion was not significant [$F_{(2,34)}$ = 0.61, MSe = 151.53, p = .56, *partial eta*^{2} = .04] and nor was the main effect of scene component [$F_{(1,17)}$ = 1.72, MSe = 962.36, p = .21, *partial eta*^{2} = .09]. There was no significant interaction between emotion and scene component [$F_{(2,34)}$ = 0.20, MSe = 65.91, p = .82, *partial eta*^{2} = .01]. Planned contrasts revealed no significant difference between the average fixation duration on emotional or neutral objects [$F_{(1,17)}$ = 0.81, p = .38], nor between negative or positive objects [$F_{(1,17)}$ = 0.06, p = .81].

Section 3.4. Discussion

There was higher specific and general recognition for positive and negative, than neutral objects. This is contrary to the predictions we made of an eradication of any emotional enhancement of memory with the presentation of stimuli in blocked lists. The pattern of results indicated that, similarly to Experiments 6, 7 and 8, the emotional enhancement for negative objects was limited to a central-peripheral trade-off in memory. Although this was not statistically significant[1] in this experiment, the pattern of results was strikingly similar to that in the previous experiments.

There was no influence of emotion on attention as measured by eye movements. The lack of attentional effects in the presence of an emotional enhancement of memory is not consistent with predictions made that the attentional effects would disappear when the emotional enhancements were eradicated, because the attentional effects have disappeared even though the emotional enhancements remain.

The presentation of stimuli in blocks produced profound differences in how participants distributed their attention across the scene; participants spent significantly longer looking at the background than object for each type of scene. This is in contrast to when stimuli were presented in mixed lists of negative, neutral and positive stimuli; participants then spent significantly longer looking at the object than background for each scene, with the differences significantly more pronounced for scenes with a negative object. It appears that changing the mode of presentation lessened participants' interest in any of the objects, as well as removing any additional interest for negative objects. Alternatively, it is possible that the change of emotion across stimuli may have led to the attentional narrowing in the other experiments where

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[1] A meta-analysis reported at the end of this chapter compared the memory results for experiments 6-10 and found no significant differences between the experiments. Although the central-peripheral trade-off with negative stimuli is not significant in this experiment, the pattern of results is similar to that in the other experiments. Therefore, in this experiment we interpret the findings as indicating there is a central-peripheral trade-off with negative stimuli.

mixed lists of stimuli were used. In this experiment, the blocking of stimuli into groups of negative, neutral or positive stimuli would have prevented this change of emotion. It would be possible to analyse the existing results of Experiment 8 to consider the influence of change in emotion. However, the possibility of this explanation occurred to us late in the process of writing up this thesis and as it would take considerable time to complete this analysis this has not been included. This remains, however, a possible explanation. Related to this idea is the possibility of carry-over of emotion across emotional stimuli (cf. McKenna & Sharma, 2004; Waters et al., 2003). It is possible that there was interference in the influence of emotion when stimuli were presented in mixed lists. The slow effects of interference that have been described in the Stroop task may have had an influence on this task, although in this experiment the inter-stimulus interval greatly exceeded the brief duration shown to be required for the carry-over of emotion ((McKenna & Sharma, 2004).

Despite no evidence of attention narrowing the emotional enhancement of visual memory specificity remained for negative and positive pictures. This suggests that instead of the narrowing of attention being a requirement for negative emotional visual memory specificity it is an associated but not necessary effect.

These findings suggest that the positive and negative emotional visual memory specificity is not due to distinctiveness of emotional stimuli as the emotional memory effects remained even when distinctiveness was controlled. However, although presenting stimuli in blocked lists controlled relative distinctiveness within the experiment by presenting stimuli in blocked lists, it is possible that the emotional stimuli are more distinctive relative to everything else in the world than neutral stimuli (cf. Talmi et al, 2007).

The aim of this experiment was to investigate the role of distinctiveness in the emotional enhancement of visual memory specificity, however, the eye movement results provided some unexpected insight into the processes responsible for the emotional enhancement of visual memory specificity. These findings suggest that visual memory specificity may not be primarily due to attentional processes at encoding (as argued by Kensinger et al., 2007b).

To emphasise the presentation of stimuli in blocks participants were told in advance the emotion of the pictures that would be subsequently presented. However, this means that we cannot disentangle the effects of distinctiveness and an advanced knowledge of the emotion when interpreting the findings of this experiment. Therefore, in the next experiment we will examine whether having an advanced knowledge of the emotion affects the way that attention is distributed across emotional and non-emotional scenes, and whether this affects the emotional memory effects. If advanced knowledge prevents the attention narrowing seen with negative emotional visual memory specificity then it would suggest the element of surprise may be the reason for attention narrowing, rather than the emotion itself. This would have implications for theories of why emotion leads to an enhancement of memory.

Section 3. Experiment 10:

Section 3.1. Introduction

In experiment 9 it was found that when stimuli were blocked according to the emotion of the object in a scene there was emotional visual specificity of memory but no evidence of attentional narrowing onto the object in negative scenes. There was a confounding variable in experiment 9 that participants were warned in advance of the emotion of the objects that would be presented in the next block in addition to the change from mixed to blocked lists of stimuli. Experiment 10 was conducted to untangle this confounding variable by presenting stimuli in the same pseudorandomised lists as experiment 6 and 7, but providing participants with a warning of the emotion that would be present in the object of the next scene.

Blocking lists of stimuli into separate emotional groups may have two effects; emotional stimuli may no longer be distinct from other stimuli around them (i.e. not distinctive relative to the surrounding stimuli) and they may also no longer be unexpected. In pseudorandomised lists participants cannot know whether a negative, neutral or positive stimulus will be displayed next and emotional stimuli may create different effects when they are experienced unexpectedly than neutral stimuli. As discussed in the chapter introduction, different neural networks are activated for unpleasant events that are expected (Herwig et al, 2007) which implies the possibility of correspondingly different processes activated for unpleasant events that are unexpected.

However, in Experiment 9 we found that the emotional enhancement of memory was not eradicated by blocking the stimuli into emotional groups. The aim of this experiment is to further investigate the factors that influence the central-peripheral trade off in the enhancement of memory. Blocking lists did not eradicate the emotional enhancement of memory but it may have affected the processes responsible for the effect because the attention narrowing as evidenced by eye movements was no longer present. Further understanding of the conditions under which this attentional narrowing is present may provide insight into the processes underlying this emotional enhancement of memory.

We predict that the warning of the emotion of the subsequent stimulus is critical in the effect that the blocking of stimuli into emotional groups had on attentional narrowing and that a similar pattern of results will be found in this experiment as in Experiment 9.

Section 3.2. Method

Design

A within-participants mixed list design was used with scenes of a neutral background and either a negative, neutral or positive object to examine the effect of a warning of the emotion of the stimulus on specific and general recognition and participants' eye movements at the time of encoding.

Participants

18 participants (9 female) took part in this experiment. All were native English speaking University of Nottingham students (mean age = 20.50 years, SD = 2.20). Informed consent was obtained from all participants. An inconvenience allowance of £3 was received by each participant for their voluntary participation.

Materials

The same materials were used as in experiment 7. An additional symbol was shown to participants before each picture to provide warning of the emotion contained within that stimulus. A sad / neutral / smiley face symbol (☹ 😐 ☺) was used to indicate that the object in the next picture would be negative, neutral or positive. These symbols were from the Wingdings font and were displayed at font size 25 in the centre of the screen instead of the fixation cross.

Procedure

Study

All aspects of the experiment were identical to those of experiment 7, apart from the warning that participants were given of the emotion of the object that would appear in the next scene. The warning took the format of a small symbol which replaced the fixation cross that appeared before the scene. Participants were told in the instructions that before each picture they would be shown a symbol which would indicate whether the next picture would be pleasant, neither pleasant nor unpleasant or unpleasant. They were shown which symbol indicated an unpleasant, neither pleasant nor unpleasant or pleasant picture before they began the experiment. (For results of study phase ratings see meta-analysis in Section 5.2, Chapter 5).

Test

This was conducted in exactly the same way as for experiment 7.

Section 3.3. Results

Results of the Memory Data

Analysis of the memory data from Experiment 10 was carried out in the same way as for experiment 6, 7, 8 and 9. (For mean data see Table 5.5). (For statistical analysis of the responses given to different items see Appendix 5.1.)

Table 5.5: Mean responses (SE) for objects and backgrounds as a function of item type (same, similar or new) and emotion type (negative, neutral or positive)

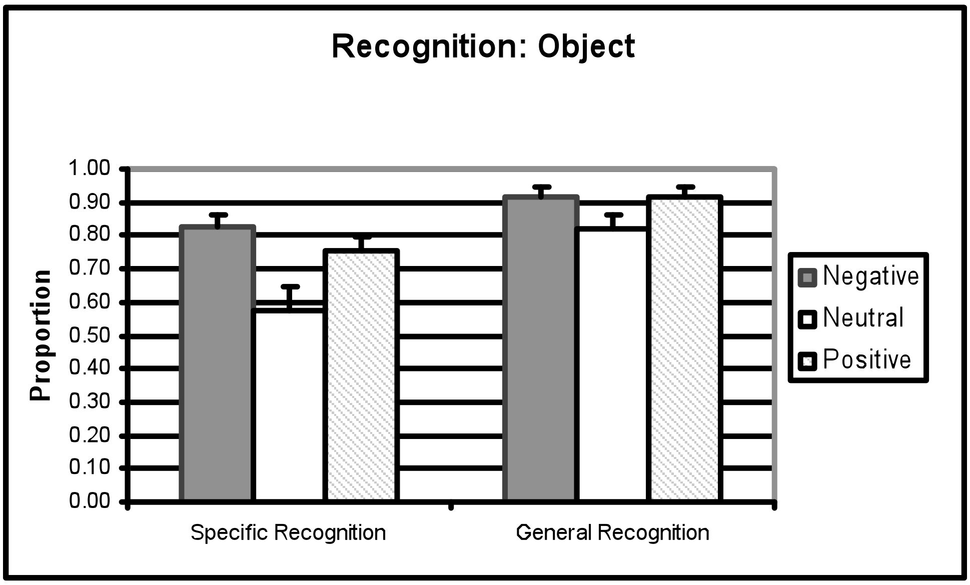
	Item type:					
	Same	Similar	New	Same	Similar	New
Response type:	Negative objects			Background (Negative)		
'Same'	.83 (.04)	.36 (.06)	.02 (.01)	.35 (.04)	.19 (.04)	.05 (.02)
'Similar'	.09 (.03)	.51 (.05)	.12 (.03)	.19 (.05)	.33 (.06)	.13 (.03)
'New'	.08 (.03)	.13 (.03)	.86 (.03)	.46 (.05)	.47 (.05)	.82 (.03)
	Neutral objects			Background (Neutral)		
'Same'	.57 (.07)	.28 (.05)	.04 (.02)	.47 (.04)	.27 (.04)	.05 (.02)
'Similar'	.24 (.05)	.42 (.06)	.15 (.04)	.22 (.03)	.27 (.06)	.13 (.03)
'New'	.18 (.04)	.31 (.05)	.81 (.04)	.31 (.04)	.46 (.04)	.82 (.03)
	Positive objects			Background (Positive)		
'Same'	.76 (.04)	.29 (.04)	0 (0)	.42 (.05)	.21 (.03)	.05 (.02)
'Similar'	.16 (.03)	.57 (.04)	.13 (.04)	.22 (.05)	.33 (.04)	.13 (.03)
'New'	.08 (.03)	.14 (.03)	.87 (.04)	.35 (.05)	.46 (.06)	.82 (.03)

NB. Data for new backgrounds is averaged across emotion as it was not possible for any of these backgrounds to be associated with an emotion.

Memory for the separate elements of the scenes was analysed by conducting separate repeated measures ANOVAs on specific recognition and general recognition. A 2 (scene component) x 3 (emotion) repeated measures ANOVA with the factors scene component and emotion on specific recognition revealed a significant main effect of scene component ($F_{(1,17)} = 57.15$, MSe = 2.48, $p < .001$, *partial eta*^{2} = .77) with greater specific recognition for the objects than backgrounds. There was no significant main effect of emotion [$F_{(1.38,23.46)} = 1.95$, MSe = 0.05, $p = .17$, *partial eta*^{2} = 0.10]. There was a significant interaction between emotion and scene component ($F_{(2,34)} = 14.54$, MSe = 0.31, $p < .001$, *partial eta*^{2} = .46). Planned contrasts revealed significantly greater specific recognition of emotional than neutral objects ($F_{(1,17)} = 19.47$, $p < .001$) and no significant difference between negative and positive objects [$F_{(1,17)} = 2.74$, $p = .12$]. Planned contrasts revealed no significant difference in specific recognition for backgrounds which had been initially presented with an emotional or neutral object [$F_{(1,17)} = 2.37$, $p = .14$] nor with a negative or positive object [$F_{(1,17)} = 2.59$, $p = .13$]. (See Figure 5.5).

For general recognition there was a significant main effect of scene component ($F_{(1,17)} = 41.78$, MSe = 1.78, $p < .001$, *partial eta*^{2} = .71) with greater general recognition for the objects than backgrounds. There was no significant main effect of emotion [$F_{(2,34)} = 1.16$, MSe = 0.02, $p = .33$, *partial eta*^{2} = .06]. There was a significant interaction between emotion and scene component ($F_{(1.46,24.83)} = 10.02$, MSe = 0.14, $p < .001$, *partial eta*^{2} = .37). Planned contrasts revealed significantly greater general recognition of emotional than neutral objects ($F_{(1,17)} = 8.19$, $p < .05$) but no significant difference between negative and positive objects [$F_{(1,17)} < 0.01$, $p = 1.00$].

Planned contrasts revealed the impairment in general recognition for backgrounds which had been displayed with an emotional than neutral object was approaching significance [$F_{(1,17)} = 3.85$, $p = .07$] and there was significantly worse general recognition for backgrounds with a negative than positive object ($F_{(1,17)} = 5.82$, $p < .05$).



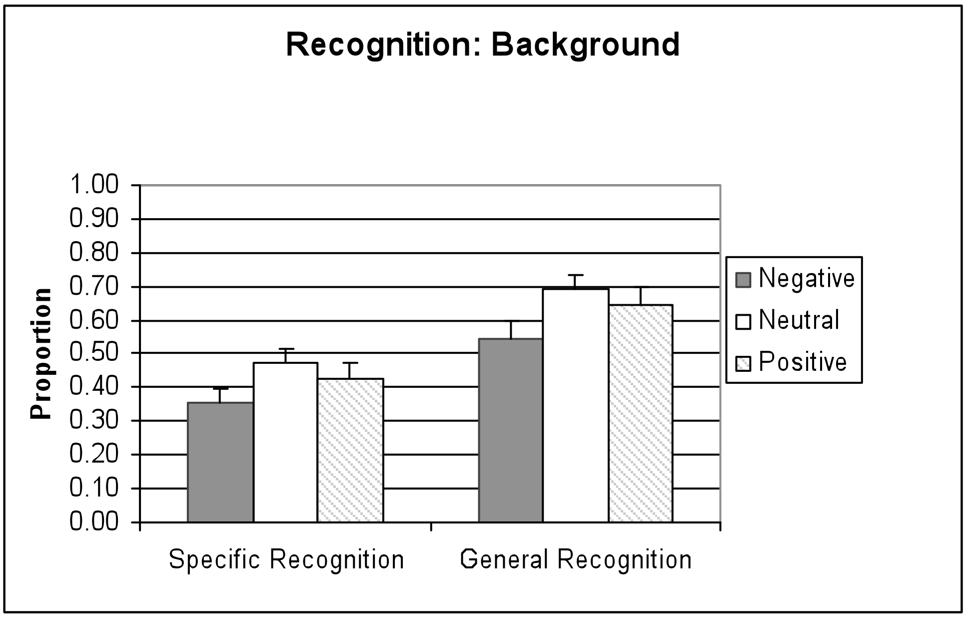


Figure 5.5. Specific and General Recognition to Negative, Neutral or Positive objects presented with Neutral Backgrounds and Neutral Backgrounds presented with Negative, Neutral or Positive objects

Results of Eye Movement Analysis

Data were extracted and analysed in exactly the same way as for experiments 7, 8, and 9. Repeated measures ANOVAs were used to examine whether the emotion of the object (negative, neutral, positive) and scene component (object, background) interacted with the different eye movement measures (See Table 5.6). The following ANOVAs were also conducted with the additional factor of object location (central or not central). Object location always interacted with scene component but as this factor did not interact with emotion these results are not discussed further. Additionally for average fixation duration and gaze duration there was a main effect of object location.

The number of fixations was analysed by conducting a 2 (scene component) x 3 (emotion) repeated measures ANOVA for the factors emotion and scene component and found no significant main effect for emotion [$F_{(2,34)} = 0.48$, MSe = 0.04, $p = .62$, *partial* $eta^2 = .03$]. There was a significant main effect for scene component ($F_{(1,17)} = 271.83$, MSe = 618.74, $p < .001$, *partial* $eta^2 = .94$) with significantly more fixations on the object than the background. The interaction between emotion and scene component was approaching significance [$F_{(2,34)} = 3.18$, MSe = 1.10, $p = .05$, *partial* $eta^2 = .16$]. The number of fixations made were further analysed by examining the number of fixations made on the object as a proportion of the total number of fixations on the scene (fixations on the object/fixations on the object + fixations on the background). There was an average proportion (S.E.) of .79 (.02) on scenes with a negative object, .76 (.02) on scenes with a neutral object and .76 (.02) on scenes with a positive object. A repeated measures ANOVA on this proportion with the factor emotion revealed the main effect was approaching significance [$F_{(2,34)} = 2.61$, MSe = 0.01, $p = .09$, *partial* $eta^2 = .13$]. Planned contrasts revealed no significant difference between the proportion between scenes with an emotional and neutral object [$F_{(1,17)} = 0.76$, $p = .39$], but the proportion was significantly greater for scenes with a negative than positive object ($F_{(1,17)}$ = 4.78, $p < .05$).

Table 5.6. Eye measurements on object or background scene components for stimuli of negative, neutral or positive emotions

Emotion	Object	Background
	No. of Fixations	
Negative	7.06 (.19)	1.87 (.15)
Neutral	6.72 (.24)	2.08 (.17)
Positive	6.68 (.21)	2.14 (.19)
	Total gaze duration (ms)	
Negative	1405.13 (59.61)	356.32 (25.36)
Neutral	1345.25 (58.15)	404.44 (33.90)
Positive	1345.40 (58.04)	414.71 (34.02)
	Mean Fixation Duration (ms)	
Negative	206.16 (9.20)	203.21 (8.53)
Neutral	206.70 (8.94)	199.88 (9.60)
Positive	205.98 (9.07)	206.47 (10.39)

The total gaze duration was analysed with a 2 (scene component) x 3 (emotion) repeated measures ANOVA with the factors emotion and scene component. There was no significant main effect of emotion [$F_{(2,34)}$ = 0.34, MSe = 373.25, p = .72, *partial* eta^2 = .02] but there was a significant main effect of scene component ($F_{(1,17)}$ = 186.47, MSe = 2.56^{E7}, $p < .001$, *partial* eta^2 = .92) with significantly longer total gaze durations on the object than the background of the scene. There was no significant interaction between emotion and scene component [$F_{(2,34)} = 2.15$, MSe = 38587.27, $p = .13$, *partial* $eta^2 = .11$]. (See Figure 5.6).

The total gaze duration was also analysed by examining the total gaze duration on the object as a proportion of the total gaze duration on the entire scene (total gaze duration on the object/ total gaze duration on the object + total gaze duration on the background). There was an average proportion (S.E.) of .79 (.02) on scenes with a negative object, .77 (.02) on scenes with a neutral object and .76 (.02) on scenes with a positive object. A repeated measures ANOVA on this proportion with the factor emotion revealed no significant main effect ($F_{(2,34)} = 2.31$, MSe = 0.01, $p = .15$, *partial* $eta^2 = .11$). Planned contrasts revealed no significant difference between the proportion between scenes with an emotional and neutral object [$F_{(1,17)} = 0.43$, $p = .52$], but the proportion was significantly greater for scenes with a negative than positive object ($F_{(1,17)} = 5.01$, $p < .05$).

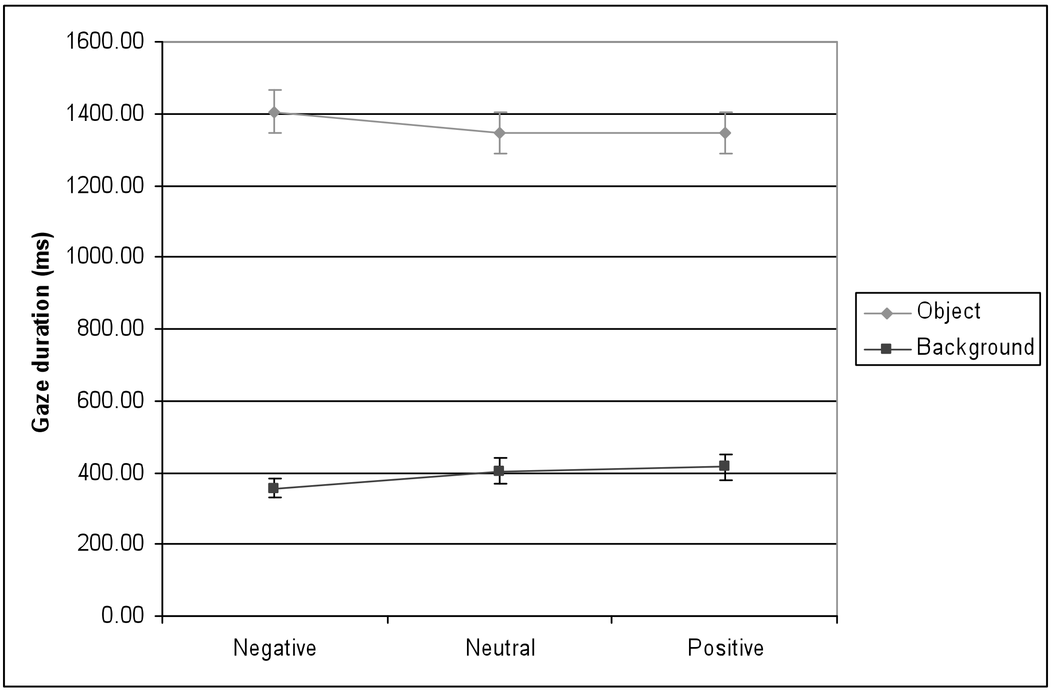


Figure 5.6. Average gaze duration on object and background scene components of scenes with a negative, neutral or positive object

The average fixation duration was analysed by conducting a 2 (scene component) x 3 (emotion) repeated measures ANOVA with the factors emotion and scene component. There was no significant main effect for emotion [$F_{(2,34)} = 0.31$, MSe = 77.90, $p = .74$, *partial eta*^{2} = .02] nor for scene component [$F_{(1,17)} = 1.35$, MSe = 258.27, $p = .26$, *partial eta*^{2} = .07]. There was also no significant interaction between emotion and scene component [$F_{(2,34)} = 0.41$, MSe = 120.25, $p = .67$, *partial eta*^{2} = .02]. Planned contrasts for the average fixation duration revealed no difference for emotional or neutral objects [$F_{(1,17)} = 0.03$, $p = .86$], nor between negative or positive objects [$F_{(1,17)} < 0.01$, $p = .95$]. Planned contrasts revealed no significant difference between scenes with an emotional or neural object [$F_{(1,17)} = 0.82$, $p = .38$], nor between scenes with a negative or positive object [$F_{(1,17)} = 0.18$, $p = .67$].

Section 3.4. Discussion

There was emotional enhancement of specific recognition and general recognition for negative and positive objects. A central-peripheral trade-off was found in general recognition with the impairment to memory for backgrounds which had been presented with a negative object.

The pattern of results for the eye movement measures were similar to those found in Experiment 7. There was more attention given to objects than backgrounds in all cases with this being more exaggerated with negative objects where an even greater proportion of attention was paid to the object than background. This was revealed in measurements of number of fixations and gaze duration. There was no significant difference in average fixation duration.

These results are not as we had predicted. We expected to find a similar pattern of results in this experiment when an advanced warning of the emotion of the stimulus was given, as in Experiment 9 when stimuli were presented in blocks of emotion. Instead, we found emotional enhancement of recognition for both positive and negative emotion in specific and general recognition, with a central-peripheral trade-off for memory with negative emotion accompanied by attention narrowing. These findings suggest that the key element to the eradication lack of attention narrowing on negative stimuli was the blocking of stimuli into groups of one emotional valence, rather than the advanced warning of emotion that participants' received.

Section 4. Chapter Discussion

The purpose of this chapter had been to examine factors other than attentional effects at encoding which might explain the emotional enhancement of memory for specific visual details that we have consistently found. We considered whether associative memory, implicit memory, item distinctiveness or surprise may be involved in this effect. We found no evidence of involvement of associative memory, implicit memory or surprise in these effects but did find that item distinctiveness had an influence on the attentional effects found. With blocked emotional and neutral stimuli there was no evidence of attentional effects on negative stimuli, nevertheless the emotional enhancement and central-peripheral trade-off in memory remained.

These experiments have had unforeseen findings in that we found attentional narrowing at encoding appears not to be necessary for the emotional enhancement of specific visual details in memory. It is possible that there is a dual route to the emotional enhancement of memory, as discussed in Chapter 4. It has been argued that the effects of emotion on memory and attention are independent (Talmi et al., 2007) and alternatively, it has been argued that there may be a conscious route by which emotion enhances memory through attention and then an unconscious route, independent of attention, which is used when attentional resources are constrained (Clark-Foos & Marsh, 2008). Another possibility is that the negative emotional objects automatically grab attention as found in the emotional stroop task (e.g. Williams et al, 1997) and this leads to the impairment in memory for the peripheral background with negative emotion. This type of attention grabbing may not be possible to identify with eye movement recordings because it may not be manifest in the spatial exploration of a scene.

One aim of this chapter was to find a dissociation in factors that might be related to the positive and not negative emotional enhancement of memory, however, we have not found any factors that were related to the positive emotional enhancement of visual memory specificity. We have ruled out the involvement of item distinctiveness, surprise, implicit memory and associative memory. The implications of these findings will be further discussed in the thesis discussion as they also relate to the findings of Chapter 4.

Section 5. Comparison of encoding ratings, memory performance and eye tracking between Experiments 6, 7, 8, 9, & 10

Section 5.1. Introduction

In chapters 4 and 5 the same experimental paradigm was used in a series of experiments and therefore we compare below the results found across all experiments. Some differences in effect size and significance were found in the different experiments but the memory results found were all in the same direction. This is similar for the eye-tracking results, although a different pattern was found in Experiment 9 where blocked lists were used.

Section 5.2 Study phase results from Experiments 6 – 10

The mean ratings given in the approach/avoidance task which participants completed as the encoding task in Experiments 6 – 10 are given in Table 5.7. Individual repeated measure ANOVA analyses with the factor emotion are shown for each experiment in Table 5.8. These show that for all experiments the average ratings from participants indicated that they wanted to move closer towards the positive pictures and further away from the negative pictures.

Table 5.7. Average ratings (standard deviation) on approach/avoidance task for scenes with a negative, neutral or positive object

Experiment	Negative	Neutral	Positive
6	4.54 (1.10)	3.30 (1.11)	2.79 (0.94)
7	5.12 (0.78)	3.90 (0.30)	3.17 (0.45)
8	4.74 (0.76)	3.69 (0.58)	2.97 (0.66)
9	4.75 (0.46)	3.92 (0.52)	3.16 (0.47)
10	5.26 (0.62)	3.58 (0.46)	2.74 (0.53)

NB. For Expts 7 – 10 N=18; due to technical error recording data for Expt 6 N=15

Table 5.8. ANOVA analyses and planned comparisons on approach/avoidance task

Exp't	ANOVA	Planned comparisons (Neg > Neu)	Planned comparisons (Neu > Pos)
6	$F_{(1.20,16.79)} = 35.78$, MSe = 20.37, $p < .001$, partial eta^2 = .72	$F_{(1,17)} = 21.51$, $p < .001$	$F_{(1,17)} = 27.77$, $p < .001$
7	$F_{(2,34)} = 71.81$, MSe = 17.42, $p < .001$, partial eta^2 = .81	$F_{(1,17)} = 54.95$, $p < .001$	$F_{(1,17)} = 51.66$, $p < .001$
8	$F_{(2,34)} = 34.12$, MSe = 14.35, $p < .001$, partial eta^2 = .67	$F_{(1,17)} = 24.39$, $p < .001$	$F_{(1,17)} = 19.87$, $p < .001$
9	$F_{(2,34)} = 63.97$, MSe = 11.40, $p < .001$, partial eta^2 = .79	$F_{(1,17)} = 41.77$, $p < .001$	$F_{(1,17)} = 30.35$, $p < .001$
10	$F_{(1.47,25.01)} = 76.80$, MSe = 29.69, $p < .001$, partial eta^2 = .82	$F_{(1,17)} = 56.77$, $p < .001$	$F_{(1,17)} = 38.77$, $p < .001$

A meta-analysis analysis was conducted to compare the study phase ratings of approach/ avoidance given to the stimuli in Experiments 6 – 10. A 3 x 5 ANOVA with the within participants factor of emotion (negative, neutral, positive) and the between participants factor of experiment (6,7,8,9,10) was conducted. There was a significant main effect of emotion ($F_{(1.54,126.49)}$ = 259.97, MSe = 81.33, $p < .001$, partial eta^2 = .76), a main effect of experiment ($F_{(4,82)}$ = 2.47, MSe = 0.61, $p = .05$, partial eta^2 = .11) and a significant interaction between emotion and experiment ($F_{(8,164)}$ = 2.32, MSe = 0.72, $p < .05$, partial eta^2 = .10). Planned comparisons for the main effect of emotion revealed significantly greater ratings for negative than neutral ($F_{(1,82)}$ = 179.110, $p < .001$) and for neutral than positive ($F_{(1,82)}$ = 146.58, $p < .001$). Post-hoc analyses of Tukey's HSD were conducted to examine the interaction between emotion and experiment. This revealed only one significant result which was that ratings for neutral stimuli were significantly lower in Experiment 6 than in Experiment 9 ($p < .05$).

Section 5.2. Memory Results

The experimental stimuli were exactly the same for Experiments 6 – 10. In experiments 9 and 10 there were some adjustments made to the presentation of stimuli. These were as follows: Experiment 9 - stimuli were presented in blocks of emotion type rather than in a pseudorandomised list and participants were warned of the emotion of the stimuli in the upcoming block; Experiment 10 – participants were given a warning of the emotion of the next stimulus. The results across all of these experiments (6 – 10) showed the same pattern of emotional influence on the results but the levels of significance differed between some of the experiments. In cases where the difference was not significant but the results were in the same direction as for other experiments we interpreted the results as being consistent with earlier experiments. To test for this interpretation we analysed the influence of emotion on specific and general recognition for central and peripheral components of a scene by conducting ANOVAs separately on specific and general recognition, as in the earlier analysis reported on these measures of memory performance, but with the addition of the between-participants factor of experiment. The analysis reported within the reports of individual experiments was of planned contrasts comparing performance with emotional vs. neutral stimuli, and then further analyses to compare performance with negative vs. positive stimuli. This analysis was consistent with the theoretical predictions that we were making in each chapter. In this meta-analysis we also conducted additional bonferroni corrected t-tests to compare recognition between negative, neutral and positive items, as all of these differences are not measured using the orthogonal planned contrasts.

Section 5.2.1. Statistical Analysis

The influence of experiment on specific and general recognition was analysed by conducting separate 3 (emotion) x 2 (scene component) x 5 (experiment) for the different types of memory (see figures 5.7 and 5.8). A 3 x 2 x 5 ANOVA with the repeated measures factors of emotion and scene component and between participants factor of experiment for specific recognition revealed there was a significant main effect of scene component

($F_{(1,85)}$ = 220.26, MSe = 15.63, p < .001, *partial eta*^{2} = .72) and a significant main effect of emotion ($F_{(2,170)}$ = 5.75, MSe = 0.17, p < .01, *partial eta*^{2} = .06). The main effect of experiment was not significant [$F_{(2,170)}$ = 0.36, MSe = 0.02, p = .84, *partial eta*^{2} = .02]. The interaction between scene component and experiment was not significant [$F_{(4,85)}$ = 1.14, MSe = 0.08, p = .34, *partial eta*^{2} = .05], nor was the interaction between emotion and experiment [$F_{(8,170)}$ = 0.65, MSe = 0.02, p = .74, *partial eta*^{2} = .03]. The interaction between scene component and emotion was significant ($F_{(2,170)}$ = 31.14, MSe = 0.72, p < .001, *partial eta*^{2} = .27). The interaction between scene component*emotion* experiment was not significant [$F_{(8,170)}$ = 0.77, MSe = 0.02, p = .63, *partial eta*^{2} = .04]. Planned contrasts revealed significantly greater specific recognition of backgrounds initially presented with neutral than emotional objects ($F_{(1,89)}$ = 5.87, p < .05) and significantly worse recognition of backgrounds initially presented with negative than positive objects ($F_{(1,89)}$ = 16.52, p < .001). Planned contrasts revealed significantly greater specific recognition of emotional than neutral objects ($F_{(1,89)}$ = 42.98, p < .001) but no significant difference between the specific recognition of positive and negative objects [$F_{(1,89)}$ = 1.09, p = .30].

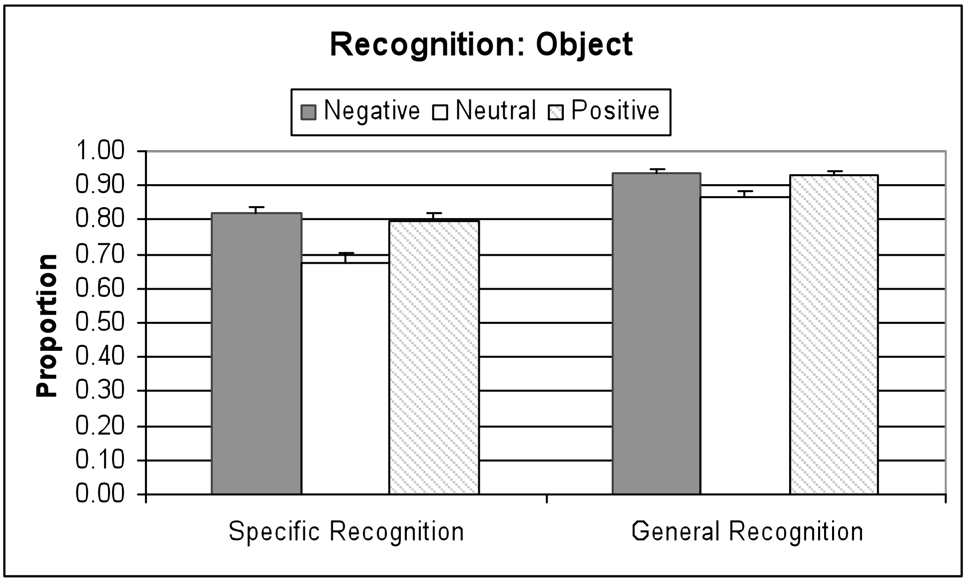


Figure 5.7. Specific and general recognition of objects as function of emotion averaged across Experiments 6, 7, 8, 9, 10

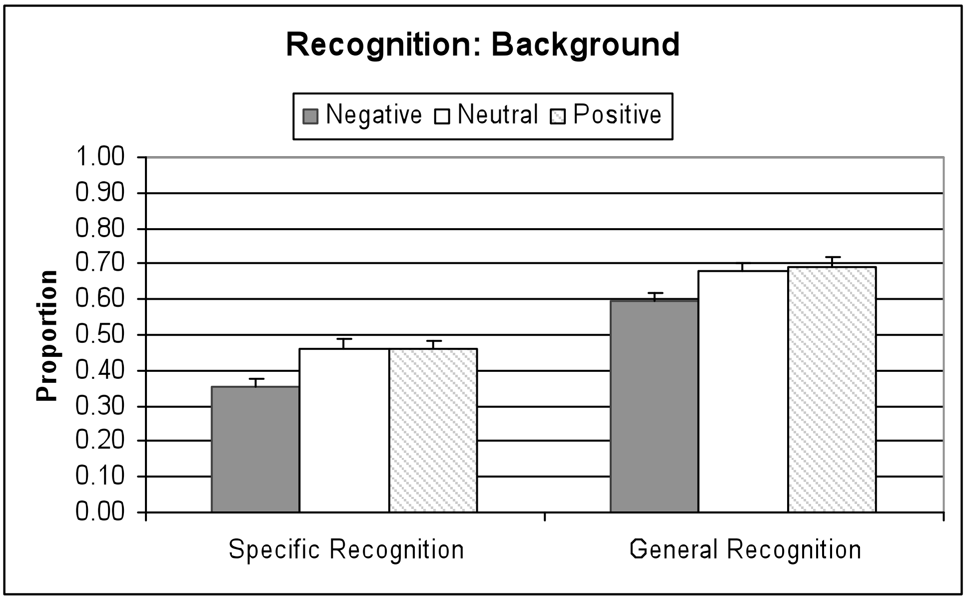


Figure 5.8. Specific and general recognition of backgrounds as function of emotion of object with which they were initially presented averaged across Experiments 6, 7, 8, 9, 10

A 3 x 2 x 5 ANOVA with the repeated measures factors of emotion and scene component and between participants factor of experiment for general recognition revealed a significant main effect of scene component ($F_{(1,85)}$ = 145.94, MSe = 8.91, p < .001, *partial eta*^{2} = .63) and a significant main effect of emotion ($F_{(2,170)}$ = 4.82, MSe = 0.10, p < .01, *partial eta*^{2} = .05). The main effect of experiment was not significant [$F_{(4,85)}$ = 0.48, MSe = 0.01, p = .75, *partial eta*^{2} = .02]. The interaction between scene component and experiment was not significant [$F_{(4,85)}$ = 0.46, MSe = 0.03, p = .77, *partial eta*^{2} = .02] and nor was the interaction between emotion and experiment [$F_{(8,170)}$ = 0.35, MSe = 0.01, p = .95, *partial eta*^{2} = .02]. The interaction between scene component and emotion was significant ($F_{(2,170)}$ = 18.41, MSe = 0.30, p < .001, *partial eta*^{2} = .18). The interaction between scene component, emotion and experiment was not significant [$F_{(8,170)}$ = 1.02, MSe = 0.02, p = .42, *partial eta*^{2}= .05]. Planned contrasts revealed the greater general recognition of backgrounds initially presented with neutral than emotional objects was approaching significance [$F_{(1,89)}$ = 3.75, p = .06] and there was significantly worse general recognition for backgrounds initially presented with negative than positive objects ($F_{(1,89)}$ = 15.16, p < .001). Planned contrasts revealed significantly greater general recognition of emotional than neutral objects ($F_{(1,89)}$ = 20.94, p < .001) but no significant difference in the general recognition of positive and negative objects [$F_{(1,89)}$ = 0.63, p = .43].

To fully investigate the emotional influence on specific and general recognition of objects and backgrounds of scenes we conducted bonferroni corrected t-tests (see Table 5.9). These confirmed the same pattern of results for specific and general recognition. There was significantly enhanced recognition of positive and negative objects compared to neutral objects, but no difference in recognition of positive or negative objects. For recognition of the backgrounds, there was reduced recognition for backgrounds initially presented with a negative object compared to backgrounds presented with a neutral or positive object, and no difference in the level of recognition for backgrounds presented with a neutral or positive object.

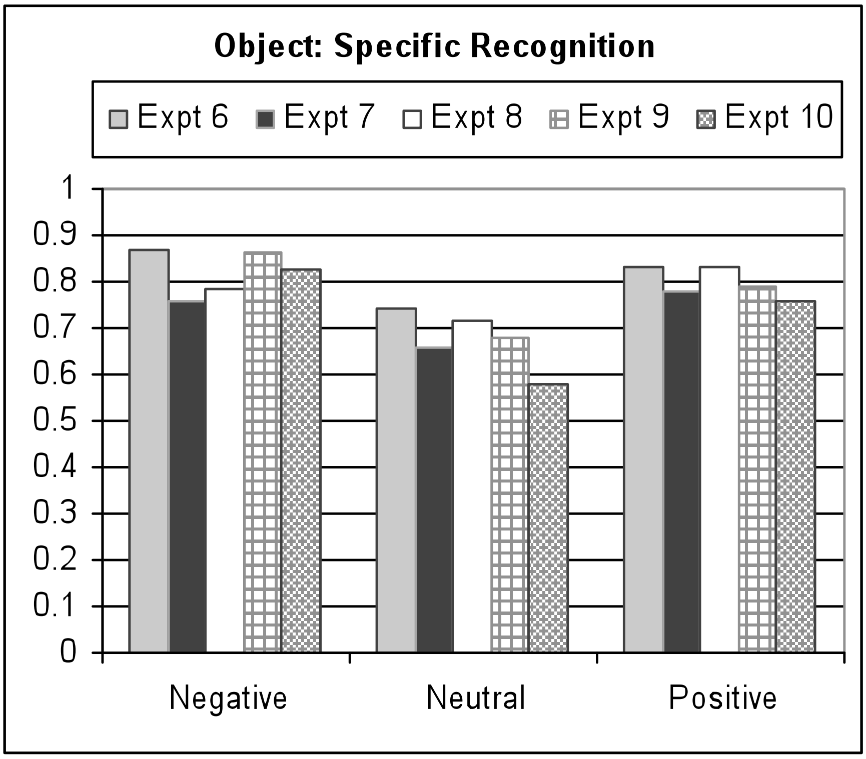
Table 5.9. Results of paired samples t-tests to compare recognition across emotions for specific and general recognition. (Bonferroni corrected *p* value = 0.004)

			t	df	*p*
Specific Recognition	Backgrounds	**Negative - Neutral**	**-4.36**	**89**	**< .001**
		Negative – Positive	**-4.06**	**89**	**< .001**
		Neutral – Positive	.10	89	.92
	Objects	**Negative – Neutral**	**5.99**	**89**	**< .001**
		Negative – Positive	1.04	89	.30
		Neutral – Positive	**-5.79**	**89**	**< .001**
General Recognition	Backgrounds	**Negative – Neutral**	**-3.60**	**89**	**< .001**
		Negative – Positive	**-3.89**	**89**	**< .001**
		Neutral – Positive	-.42	89	.67
	Objects	**Negative – Neutral**	**4.84**	**89**	**< .001**
		Negative – Positive	.80	89	.43
		Neutral - Positive	**-3.70**	**89**	**< .001**

Section 5.2.3. Discussion

We found no evidence that the pattern of memory results and the influence of emotion was any different in any of the Experiments 6 – 10. The critical interaction between scene component and emotion was evident. We found enhanced specific and general recognition for positive and negative emotional objects. This was accompanied by a central-peripheral trade-off in memory for the backgrounds which manifested in a worse specific and general recognition of the backgrounds which had been initially presented with a negative object.

The memory results for the different experiments are summarised in Figures 5.9 and 5.10. Although some levels of recognition may appear to differ between experiments, when these are compared between all experiments it becomes apparent that there are no large differences from one experiment to another but that the results from all experiments differ slightly. Statistical analysis confirmed no significant difference in levels of recognition between the different experiments.



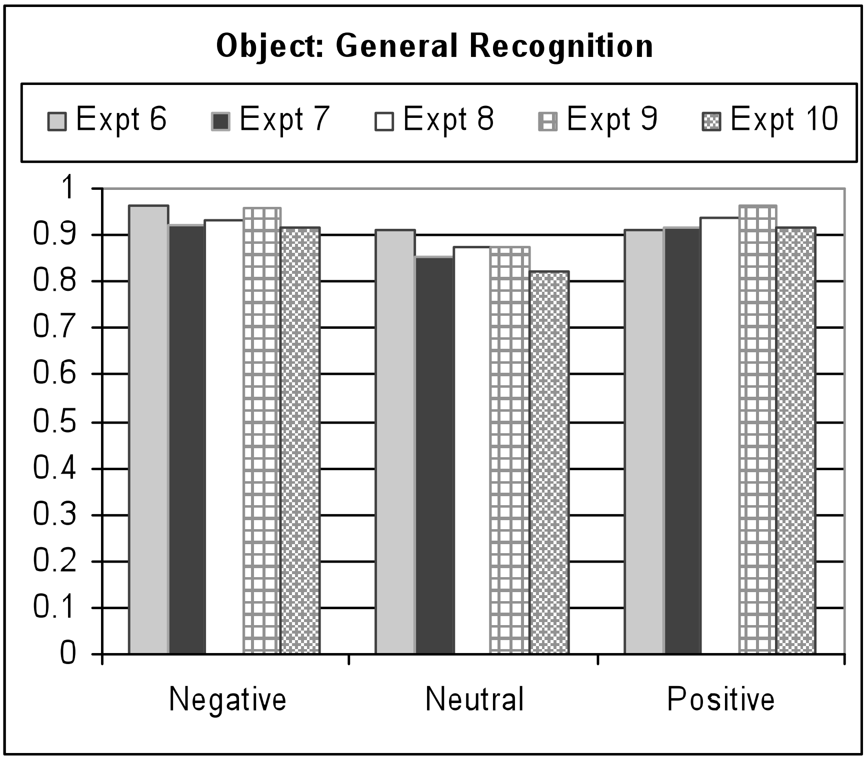
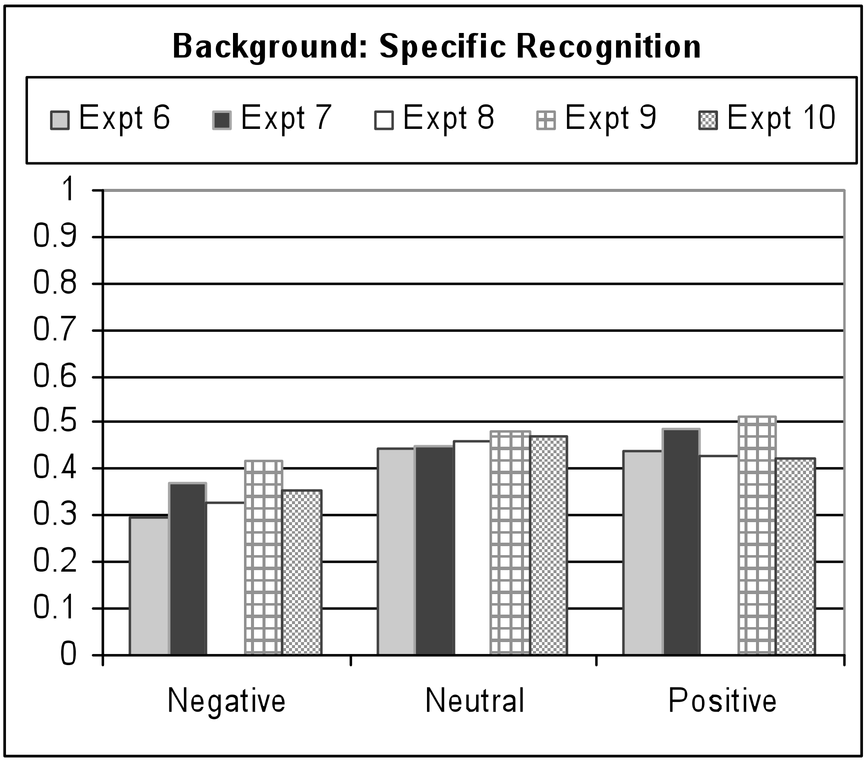


Figure 5.9. Specific and General Recognition to Objects by emotion for Experiments 6, 7, 8, 9 & 10



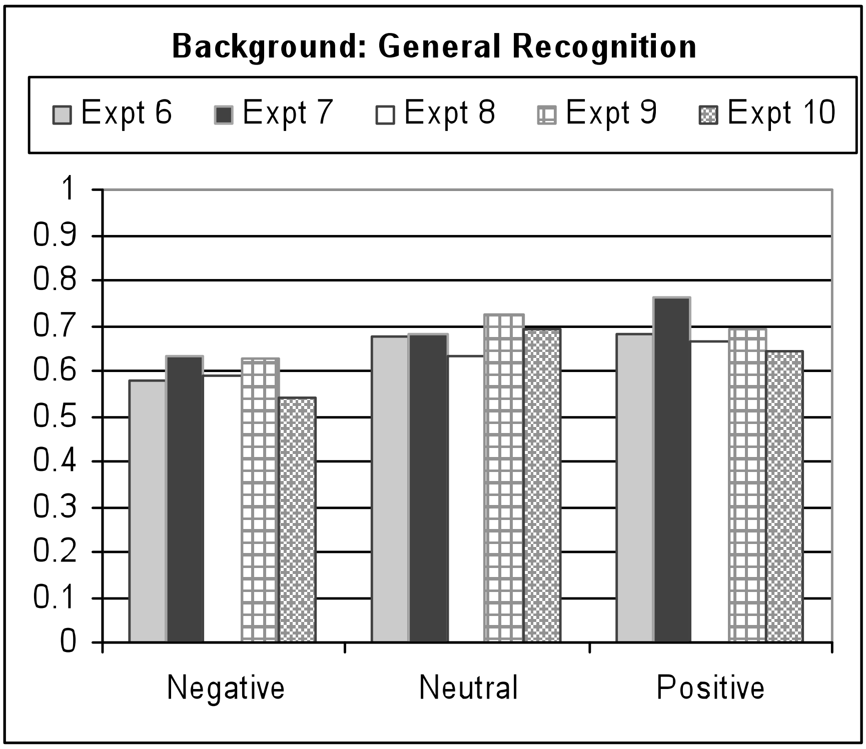


Figure 5.10. Specific and General Recognition to Backgrounds by emotion of object initially presented with for Experiments 6, 7, 8, 9 & 10

Section 5.3. Eye movement results

The same measurements of eye movements at the time of encoding stimuli were taken for Experiments 7, 8, 9 & 10. In the individual analysis of each of the experiments reported earlier we found that in Experiment 9 the attention narrowing onto a negative object in a scene found in Experiments 7, 8 and 10 was eradicated. We would predict that the eye movements for Experiment 9 will be significantly different compared to the results from the other experiments but there would be no other significant differences between the other experiments.

Section 5.3.1. Statistical analysis

The influence of emotion and scene component on eye movements across different experiments was analysed by conducting a series of 3 (emotion) x 2 (scene component) x 4 (experiment) ANOVAs on the different measures of eye movements.

Average Number of fixations

A 3 x 2 x 4 ANOVA with the repeated measures factors of emotion and scene component and between participants factor of experiment was conducted on the average number of fixations made. (See Figures 5.11 and 5.12). The main effect of emotion was not significant [$F_{(2,136)} = 0.10$, MSe = 0.01, $p = .91$, *partial* $eta^2 < .01$]. The main effect of scene component was significant ($F_{(1,68)} = 726.04$, MSe = 967.39, $p < .001$, *partial* $eta^2 = .91$) with a greater number of fixations on the object than the background. The main effect of experiment was also significant ($F_{(3,68)} = 15.59$, MSe = 19.28, $p < .001$, *partial* $eta^2 = .41$). The interaction between scene component and experiment was significant ($F_{(3,68)} =$

116.20, MSe = 154.82, $p < .001$, *partial* $eta^2 = .84$) and the interaction between emotion and scene component was significant ($F_{(2,136)} = 7.39$, MSe = 3.62, $p < .001$, *partial* $eta^2 = .10$). The interaction between emotion and experiment was not significant [$F_{(6,136)} = 0.79$, MSe = 0.05, $p = .58$, *partial* $eta^2 = .03$]. The interaction between emotion, scene component and experiment was not significant [$F_{(6,136)} = 1.03$, MSe = 0.51, $p = .41$, *partial* $eta^2 = .04$]. Post-hoc Tukey's HSD comparisons revealed that a significantly smaller average number of fixations was made in Experiment 7 than in Experiments 8 and 10, and in Experiment 9 than in Experiments 8 and 10 ($q = 4.00$, $p < .05$; $q = 8.08$, $p < .001$; $q = 4.32$, $p < .05$; $q = 8.39$, $p < .001$ respectively). The number of fixations on the object in a scene was significantly different between each of the different experiments ($p < .01$ / .001 for each combination Expt 7 vs 9 $q = 13.38$, Exp 7 vs 10 $q = 10.04$, Exp7 vs 8 $q = 5.28$, Exp 9 vs 10 $q = 23.42$, Exp 8 vs 9 $q = 18.66$, Exp 8 vs 10 $q = 4.76$). There was a significantly greater number of fixations on the object than the background in Experiments 7, 8 and 10 ($q = 22.13$, 26.85, 30.47, $p < .001$ all cases, respectively), whereas in Experiment 9 there was a significantly greater number of fixations on the background than object ($q = 3.23$, $p < .05$). A significantly reduced number of fixations were made on the object in Experiment 9 in comparison to Experiments 7, 8 and 10 ($q = 13.38$, 18.66, 23.42, $p < .001$ all cases, respectively), whereas a significantly greater number of fixations were made on the background in Experiment 9 in comparison to Experiments 7, 8 and 10 ($q = 12.94$, 12.56, 11.55, $p < .001$ all cases, respectively). Significantly fewer fixations were made on the object in Experiment 7 than Experiments 8 and 10 ($q = 5.28$, 10.04, $p < .01$, .001 respectively), and in Experiment 8 than in Experiment 10 ($q = 4.76$, p

$< .01$). Post-hoc Tukey's HSD were used to analyse the interaction between scene component and emotion and these revealed significantly greater number of fixations on the negative object in a scene than a neutral or positive object ($q = 9.60, 9.05$, $p < .001$ all cases, respectively), and a correspondingly significantly fewer number of fixations on the background in scenes with a negative object than a neutral or positive object ($q = 10.36, 9.03$, $p < .001$ all cases, respectively). A significantly greater number of fixations were made on the object than background in scenes with a negative, neutral or positive object ($q = 24.68, 20.46, 20.86$ respectively).

Planned contrasts revealed a significantly smaller number of fixations on backgrounds which were initially presented with an emotional than neutral object ($F_{(1,71)} = 4.54$, $p < .05$) and a significantly smaller number of fixations on backgrounds presented with a negative than positive object ($F_{(1,71)} = 10.04$, $p < .01$). Planned contrasts revealed no significant difference in the number of fixations made on emotional and neutral objects [$F_{(1,71)} = 3.24$, $p = .08$] but there were a significantly greater number of fixations on negative than positive objects ($F_{(1,71)} = 10.05$, $p < .01$).

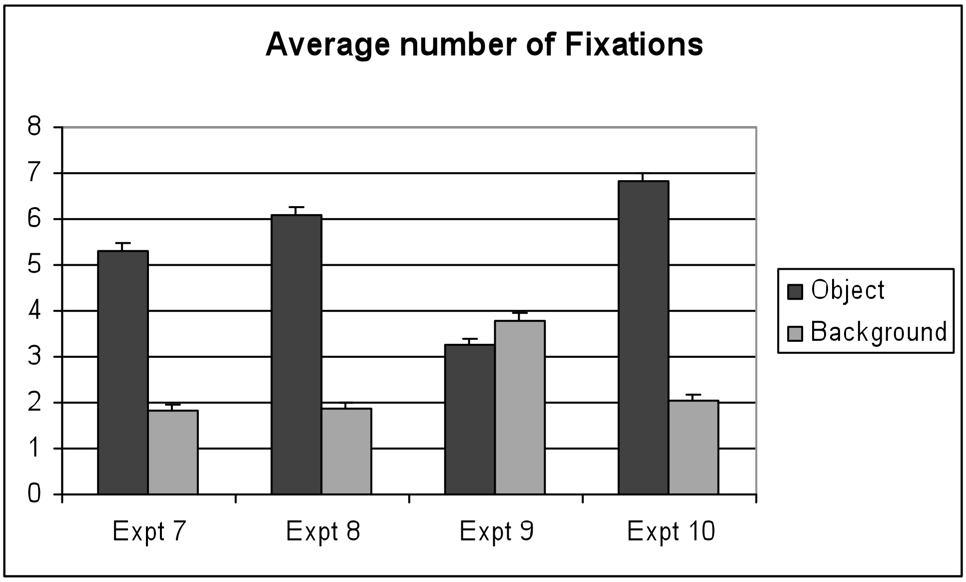


Figure 5.11. Experiments 7- 10: Average number of fixations on different components of scene

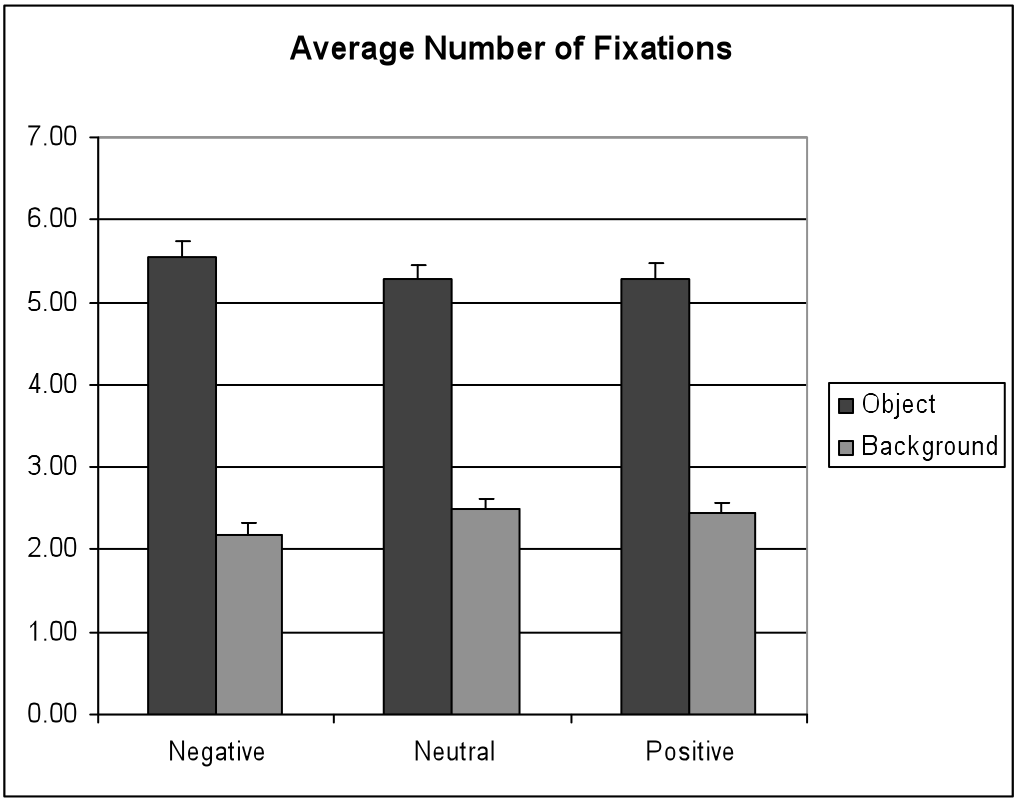


Figure 5.12. Experiments 7 – 10: Aggregated values for average number of fixations on different components of scenes according to emotional valence of object

The number of fixations made on different scene components was further analysed by examining the proportion of fixations made on the object as a proportion of fixations made on the entire scene (see Figure 5.13). A 3 (emotion) x 4 (experiment) ANOVA with the repeated measures factor of emotion and the between-participants factor of experiment revealed a main effect of emotion ($F_{(2,136)} = 7.65$, MSe = 0.03, $p < .001$, *partial* $eta^2 = .10$) and a main effect of experiment ($F_{(3,68)} = 1112.28$, MSe = 0.40, $p < .001$, *partial* $eta^2 = .83$). The interaction between emotion and experiment was not significant [$F_{(6,136)} = 0.82$, MSe < 0.01, $p = .56$, *partial* $eta^2 = .04$]. Planned contrasts revealed this proportion was significantly greater for scenes with an emotional and neutral object ($F_{(1,68)} = 4.69$, $p < .05$), and significantly greater proportion for scenes with a negative than positive object ($F_{(1,68)} = 11.25$, $p < .001$). The significant main effect of experiment was further explored using post-hoc comparisons with a Bonferroni correction for multiple tests. These revealed that this proportion was significantly reduced for Experiment 9 in comparison to all other Experiments, but there were no other differences (Expt 7 > Expt 9, $p < .001$; Expt 10 > Expt 9, $p < .001$; Expt 8 > Expt 9, $p < .001$).

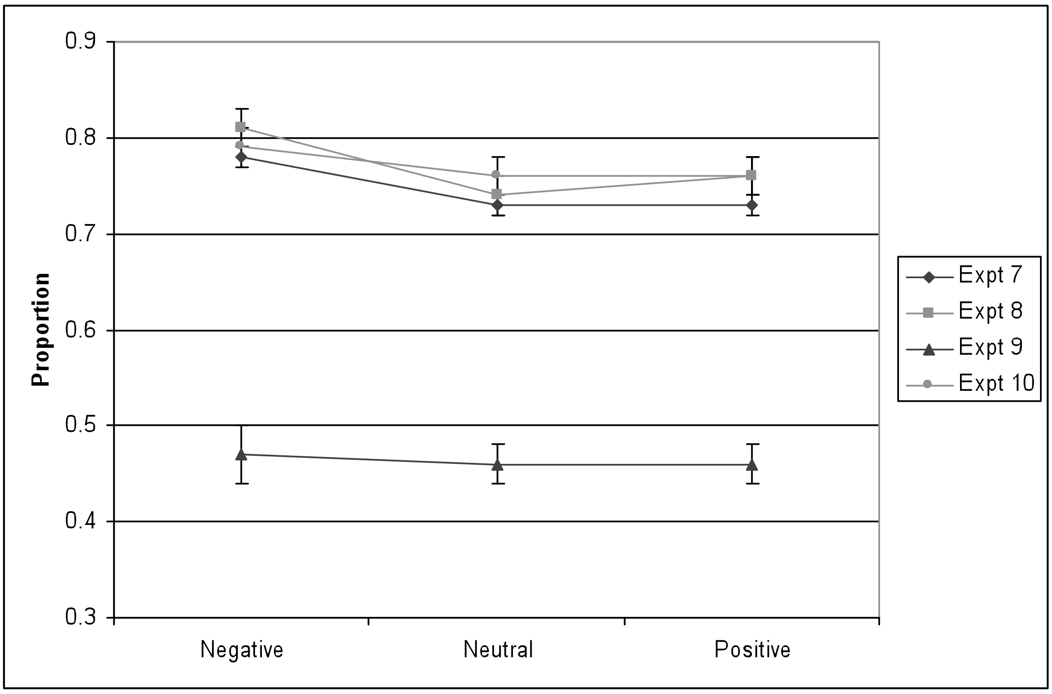


Figure 5.13. Proportion of number of fixations on the object in comparison to scene as a whole.

Average total gaze duration

A 3 x 2 x 4 ANOVA was conducted on the total gaze duration for the repeated measures factors emotion and scene component and the between-participants factor of experiment. (See Figure 5.14). This revealed a significant main effect of scene component ($F_{(1,68)}$ = 569.24, MSe = 5.09^{E7}, p < .001, *partial eta*^{2} = .89) with longer total gaze duration on the object than background. The main effect of emotion was not significant [$F_{(2,136)}$ = 0.58, MSe = 468.15, p = .56, *partial eta*^{2} = .01] and nor was the main effect of experiment [$F_{(3,68)}$ = 2.38, MSe = 22861.75, p = .08, *partial eta*^{2} = .10]. The interaction between emotion and experiment was not significant [$F_{(6,136)}$ = 0.35, MSe = 280.93, p = .91, *partial eta*^{2} = .02]. The interaction between scene component and experiment was significant ($F_{(3,68)}$ = 86.30, MSe = 7721847.53, p < .001, *partial eta*^{2} = .79) and the interaction between emotion and scene component was significant

($F_{(1.79,5.37)} = 7.12$, MSe = 232535.77, $p < .001$, *partial eta*^{2} = .10). The interaction between emotion, scene component and experiment was not significant [$F_{(6,136)} = 0.95$, MSe = 27609.21, $p = .47$, *partial eta*^{2} = .04]. Post-hoc Tukey's HSD pair-wise comparisons were conducted to further investigate the significant interactions between scene component and experiment and between emotion and scene component. Total gaze duration on the object was significantly lower in Experiment 9 than in Experiments 7, 8 and 10 (q = 22.56, 25.31, 22.38, $p < .001$ all cases, respectively). Correspondingly, total gaze duration on the background was significantly longer in Experiment 9 than in Experiment 7, 8 and 10 (q = 21.08, 22.48, 24.64, $p < .001$ all cases, respectively). Total gaze duration was significantly longer on the object than background in Experiments 7, 8 and 10 (q = 22.00, 24.35, 23.91, $p < .001$ all cases, respectively). There was a significantly longer total gaze duration on the negative object in a scene than a neutral or positive object (q = 20.62, 20.42, $p < .001$ all cases, respectively), and a correspondingly significantly lower total gaze duration on the background in scenes with a negative object than a neutral or positive object (q = 18.46, 19.37, $p < .001$ all cases, respectively). There was significantly longer total gaze duration on the object than background in scenes with a negative, neutral or positive object (q = 21.97, 18.27, 18.20 respectively).

Planned contrasts revealed no significant difference in the total gaze duration on the object in a scene between emotional and neutral objects [$F_{(1,71)} = 3.34$, $p = .07$] but there was significantly longer total gaze duration on negative than positive objects ($F_{(1,71)} = 12.08$, $p < .001$). Planned contrasts revealed significantly lower total gaze durations on backgrounds with an emotional than neutral object ($F_{(1,71)}$ = 72.60, p < .001) and lower total gaze durations on backgrounds with a negative than positive object ($F_{(1,71)}$ = 115.08, p < .001).

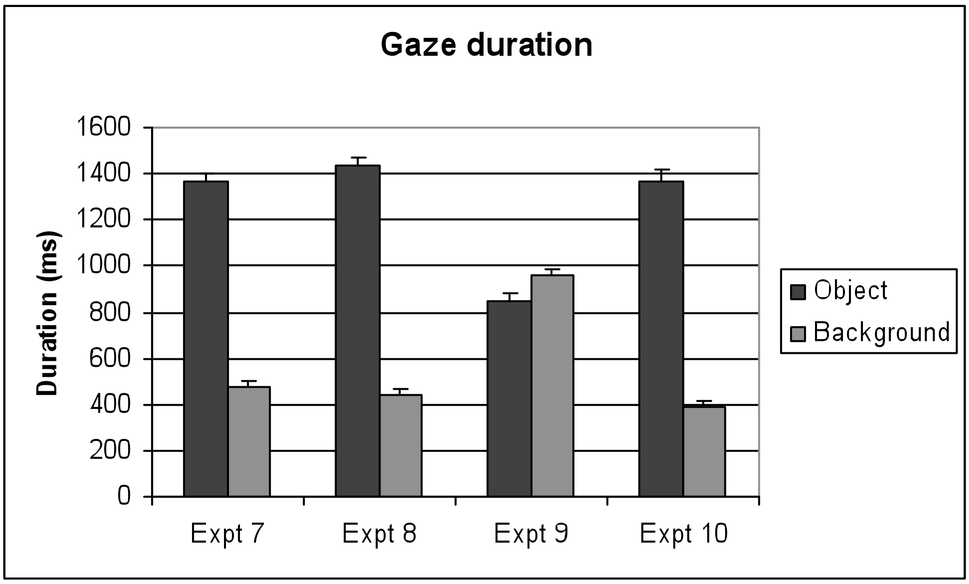


Figure 5.14. Experiments 7 – 10: Average total gaze duration on different components of scene

The average total gaze duration on different scene components was further analysed by examining the proportion of gaze duration on the object as a proportion of total gaze duration on the entire scene (see Figure 5.15). A 3 (emotion) x 4 (experiment) ANOVA with the repeated measures factor of emotion and the between-participants factor of experiment revealed a main effect of emotion ($F_{(2,136)}$ = 6.14, MSe = 0.03, p < .01, *partial eta*^{2} = .09) and a main effect of experiment ($F_{(3,68)}$ = 106.65, MSe = 0.39, p < .001, *partial eta*^{2} = .83). The interaction between emotion and experiment was not significant [$F_{(6,136)}$ = 0.94, MSe < 0.01, p = .47, *partial eta*^{2} = .04]. Planned contrasts revealed no significant difference between this proportion for scenes with an emotional and neutral object [$F_{(1,68)} = 2.30$, $p = .13$], but did reveal a significantly greater proportion for scenes with a negative than positive object ($F_{(1,68)} = 10.93$, $p < .01$). The significant main effect of experiment was further explored using post-hoc comparisons with a Bonferroni correction for multiple tests. These revealed that this proportion was significantly reduced for Experiment 9 in comparison to all other Experiments, but there were no other differences (Expt 7 > Expt 9, $p < .001$; Expt 10 > Expt 9, $p < .001$; Expt 8 > Expt 9, $p < .001$).

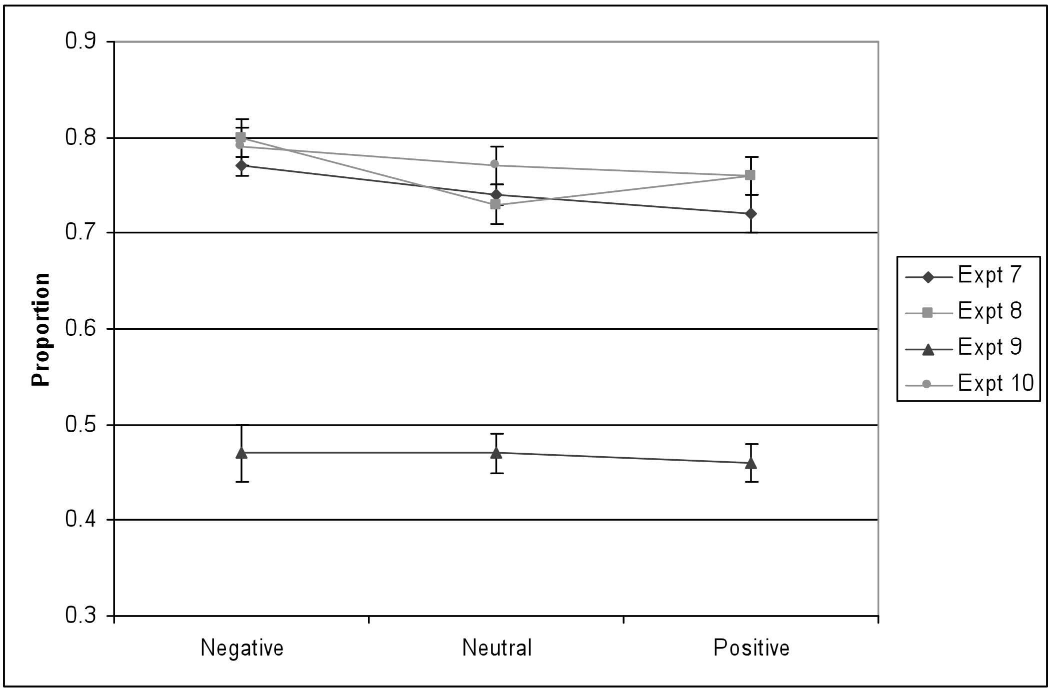


Figure 5.15. Proportion of total gaze duration on the object in comparison to scene as a whole

Average fixation duration

A 4 x 3 x 2 ANOVA was conducted to examine the influence of experiment, emotion and scene component on the average fixation duration. (See Figure 5.16). An ANOVA with the repeated measures factors of emotion and scene component and the between-participants factor of experiment revealed a significant main effect of experiment ($F_{(3,68)}$ = 9.10, MSe = 40244.92, $p < .001$, *partial eta*^{2} = .28). The main effect of emotion was not significant [$F_{(2,136)}$ = 1.04, MSe = 516.75, $p = .36$, *partial eta*^{2} = .02], nor was the main effect of scene component [$F_{(1,68)}$ = 1.92, MSe = 1151.24, $p = .17$, *partial eta*^{2} = .03]. The interaction between scene component and experiment was significant ($F_{(3,68)}$ = 3.74, MSe = 2246.21, $p < .05$, *partial eta*^{2} = .14). The interaction between emotion and experiment was not significant [$F_{(6,136)}$ = 1.61, MSe = 799.07, $p = .15$, *partial eta*^{2} = .07], nor was the interaction between emotion and scene component [$F_{(2,136)}$ = 1.05, MSe = 587.08, $p = .35$, *partial eta*^{2} = .01] and nor was the interaction between emotion, scene component and experiment ($F_{(6,136)}$ = 1.58, MSe = 886.03, $p = .16$, *partial eta*^{2} = .07]. The significant main effect of experiment and significant interaction between scene component and experiment were further explored using Tukey's HSD, only significant differences are reported. This revealed that average fixation durations were significantly less in Experiment 10 than in Experiments 7, 8 and 9 ($q = 6.64$, $p < .001$; $q = 4.15$, $p < .05$; $q = 6.05$, $p < .001$ respectively). The average fixation durations were significantly longer on the object and on the background for both Experiments 7 and 9 than Experiment 10 (Object: $q = 4.21$, $p < .05$; $q = 4.37$, $p < .05$, Background: $q = 5.18$, $p < .01$; $q = 4.18$, $p < .05$ respectively). There was significantly longer average fixation durations on the background than object in Experiments 7 and 8 ($q = 3.64$, $p < .05$; $q = 3.00$, $p < .05$ respectively).

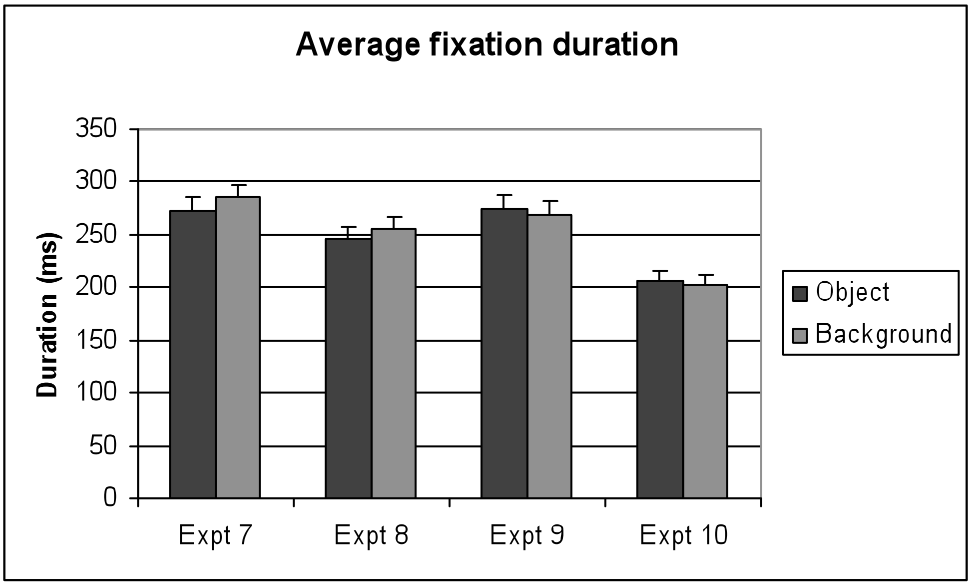


Figure 5.16. Experiments 7 – 10: Average fixation duration on different components of scene

Section 5.3.2. Discussion

The analysis to compare eye movements across Experiments 7, 8, 9 and 10 confirmed two findings from the analysis of the individual experiments already reported and revealed two additional new findings.

This meta-analysis confirmed that in Experiments 7, 8 and 10 participants looked for longer and more often at the object than background components of a scene (as measured by total gaze duration and number of fixations), whereas in Experiment 9 participants looked for longer and more often at the background than object. However, unexpectedly there was no significant interaction between emotion, scene component and experiment for number of fixations or total gaze duration. This means that there is no evidence of a lack of attention narrowing onto the negative object in scenes in Experiment 9. Although, we can conclude that despite the radically different visual search strategies used by participants viewing blocked stimuli in Experiment 9 there was no difference in the influence of emotion on the pattern of memory results.

This meta-analysis also confirmed that across all experiments together visual attention was narrowed onto the negative object in a scene with participants looking for longer and more often at a negative than a neutral or positive object. Correspondingly, participants looked for a shorter total gaze duration and less often at the backgrounds in scenes with a negative than neutral or positive object. This finding demonstrated the resilience of the central-peripheral trade-off in eye movements that was found in 3 experiments, and corresponded to the central-peripheral trade-off in memory.

The two new key findings that were revealed by this meta-analysis relate to the average fixation duration. Firstly, there was a shorter average fixation duration in Experiment 10 than in Experiments 7, 8 and 9.

One possibility is that the shorter average fixation duration in Experiment 10 reflects a more extensive search of the scene as participants move their eyes around more. The cue of the emotion may have increased the salience of the emotion of that scene and lead participants to a more extensive search of the scene to check the location of the source of the emotion. Alternatively, the cue of the emotion may have enhanced the perceived distinctiveness of each item and piqued the interest of participants to a greater degree than in the other experiments, therefore leading them to search the scene to a greater extent.

Alternatively, average fixation duration has been reported to reflect level of visual processing complexity (e.g. Rayner & Pollatsek, 1989) and it may be that the scenes were easier to process in Experiment 10 because participants were aware of the emotion of each scene before they saw it. In Experiment 9 participants were also aware of the emotion of each scene before they saw it, however, it may be that a reminder is needed before each item (rather than at the start of the block) for participants to retain this as salient information. If this were the case we would expect that reaction times for the encoding task in Experiment 10 would be shorter than for Experiment 9. Unfortunately reaction times were not recorded as part of the experimental procedure for the encoding task and therefore it is not possible to easily test this claim.

Another explanation, based on the claim that reduced average fixation duration reflects reduced visual processing complexity, may be that receiving a warning of the emotion in Experiment 10 makes the encoding task (an approach/avoidance task to measure perception of emotion conveyed by scene) easier and therefore the processing of the picture easier. In Experiment 9, although the warning of the emotion should have made the encoding task more easy it may be that blocking the pictures into groups of the same emotion may have made it more difficult for participants to rate each individual scene for emotion because further discrimination would have been required between items as participants may have implicitly made comparisons between items within each block. If this were the case we would expect a greater variance in the ratings from the approach / avoidance task for each emotion in Experiment 9, where emotion groups were blocked, than in Experiment 10. We tested this by analysing the standard deviation in ratings for each participant for scenes of each emotional type. We found a greater variance in ratings for each of the emotional groups in Experiment 9 than in Experiment 10, although these differences were not statistically significant they do suggest that this may be a viable explanation for these results (see Appendix 5.2 for means and analysis).

Secondly, there was a shorter average fixation duration on the object than background in Experiments 7 and 8, but this was not the case in Experiments 9 and 10. This may suggest that the object was more difficult to visually process in Experiments 7 and 8 because it was the source of emotion within the scene but this emotion was unexpected, compared to Experiments 9 and 10 where the emotion was expected and therefore perhaps easier to visually process.

Section 5.4. Discussion

In summary, in this meta-analysis of the memory and eye movement results from Experiments 6, 7, 8, 9 and 10 we have found clear evidence in the memory results of an emotional enhancement of memory for negative and positive objects and an impairment in memory for the background of scenes with a negative object, with a clear pattern of results across all experiments. The results of the eye movements are not so straightforward. We have clear evidence that there is focusing of visual attention on to a negative object in a scene but not on to a positive object. There was a dramatically different pattern of eye movements in Experiment 9 when emotional and neutral stimuli were blocked but despite this the enhancement of memory for negative and positive objects remained.

Chapter 6. Discussion

In the final chapter of this thesis I will summarise my research findings, discuss ideas for continuing this research, and consider how the research in this thesis informs a number of issues: the choice of experimental stimuli in the study of emotion; the influence of task instructions on experimental paradigms and the influence of emotion on different memory processes.

Section 6.1. Summary of findings

In this thesis I have examined the influence of emotion on memory. I began in chapter 2 by considering how factors at the time of retrieving a memory may be influenced by emotion and proposed that emotions of different valence may encourage the use of different strategies to retrieve memories. I found an emotional enhancement of memory for pictures which was restricted to positive emotion and only present with recognition tasks which encouraged the use of a nonanalytic processing strategy at retrieval, that is to say with a traditional / straightforward recognition task and a nonanalytic recognition task (see Figure 6.1). An additional and unexpected finding was that when recognition was followed by a Remember/Know/Guess judgement for each item there was no emotional enhancement of memory.

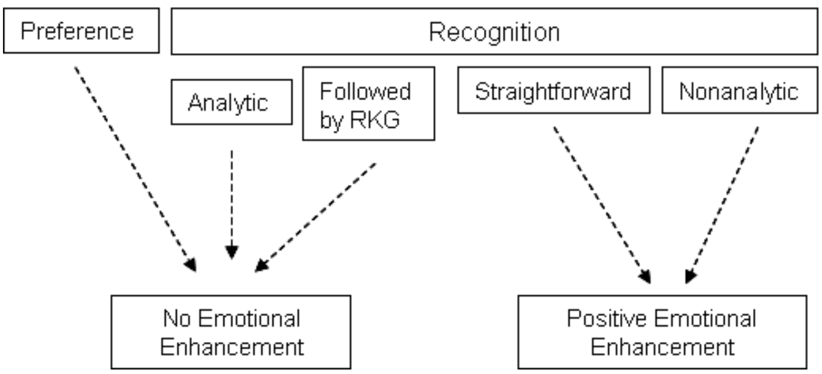


Figure 6.1 Summary of findings from Chapter 2

In chapter 3 I addressed two research questions. Firstly, I extended the research of chapter 2 by designing a within participants version of the between participants paradigm which had been used to examine retrieval strategies. Unfortunately the experimental paradigm did not successfully translate into a within participants design, however, the experiments did suggest that there may be interesting implications of using different methodologies to investigate the effects of emotion on memory. In the next phase of research in this chapter I continued the exploration of different paradigms. Specifically, I compared the pattern of results from the well-know Remember/Know/New paradigm (Tulving, 1985) with the more recently developed Same/Similar/New paradigm which has been used to demonstrate some interesting effects with emotion and memory (e.g. Kensinger, Garoff-Eaton, & Schacter, 2006). A memory advantage for negative emotional stimuli was found in both paradigms (see Figure 6.2). The results from the Same/Similar/New paradigm appeared more straightforward to interpret in the context of this type of experiment with the advantage of clear and well-defined criteria by which participants chose their responses. Therefore, I continued with this experimental paradigm in the investigation of cognitive processes underlying the influence of emotion on memory.

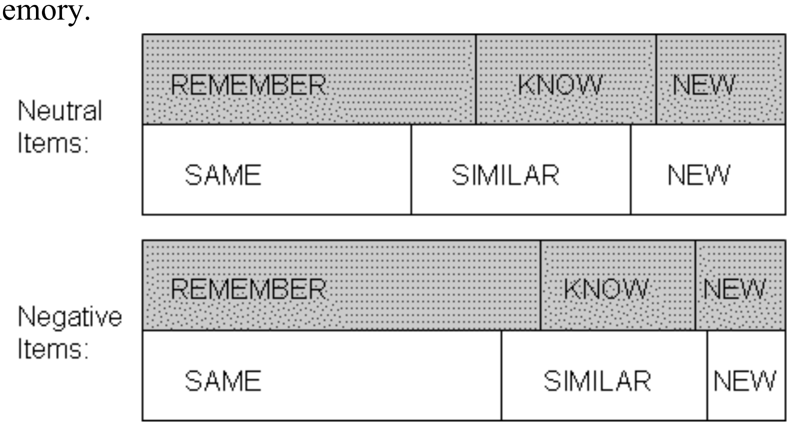


Figure 6.2 Summary of findings from Chapter 3

In chapter 4 I extended the experimental stimulus set I had used with the Same / Similar / New paradigm to also include positive emotional stimuli. Emotional enhancement of memory for specific visual details was found to be present for both negative and positive emotion. In the next experiments objects were presented as part of a contextual scene and memory was assessed separately for central and peripheral scene components. A central-peripheral trade-off in memory for specific visual details was found with negative emotion, but not with positive emotion. The remainder of this thesis used this stimulus set and experimental paradigm to explore the cognitive processes underlying these emotional enhancements of visual specificity of memory. At this stage of the thesis the focus of the thesis shifted to examining the role of factors at the time of encoding information into memory as the importance of these processes had been suggested by earlier research. Eye movements at the time of encoding the pictures into memory were recorded as a measure of attention and the spatial distribution of visual attention was found to be narrowed onto the negative object in scenes, but no attentional effects were found with scenes with a positive object.

At this point the involvement of attentional effects in the negative emotional enhancement of memory appeared to have been confirmed and therefore further experiments aimed to explore other factors which lead to the enhancement of memory by positive emotion. As attention appeared to be important, the influence of these factors on visual attention was also examined. Relative distinctiveness and the unexpected nature of emotional stimuli were explored by blocking stimuli into groups by emotion and giving participants warning of the emotion of the next stimulus, but these were found not to be responsible for the emotional effects. Memory for the association between central and peripheral elements of a scene and implicit memory were also examined as it was thought these might explain the positive emotional enhancement of memory without impairment for memory of peripheral elements. However, no emotional enhancement of these types of memories was found. From chapter 5 no firm conclusions could be made to explain positive emotional enhancement of memory, however, there were some unexpected findings regarding spatial visual attention. When stimuli were blocked into groups by emotion the attentional narrowing observed with mixed lists of emotional and neutral stimuli was removed but despite this the emotional enhancement for positive and negative emotion remained. This suggested that the narrowing of visual spatial attention is an associated, rather than causal, factor in the enhancement of memory by negative emotion. Figures 6.3 and 6.4 summarise the experimental findings with negative emotion and positive emotion that were reported in chapters 4 and 5. With negative emotion an enhanced visual memory specificity was found with effects of attention narrowing and a central-peripheral trade-off in memory, but no effects of implicit memory or associative memory. Experimental manipulations of blocking groups of stimuli and warning of emotion still led to visual memory specificity but attentional narrowing effects were removed with blocked stimuli (see Figure 6.3). With positive emotion an enhanced visual memory specificity was found but there were no effects found of central/peripheral trade-off, attention narrowing, implicit memory or associate memory. Experimental manipulations of blocking groups of stimuli and providing a warning of emotion still led to enhanced visual memory specificity (See Figure 6.4).

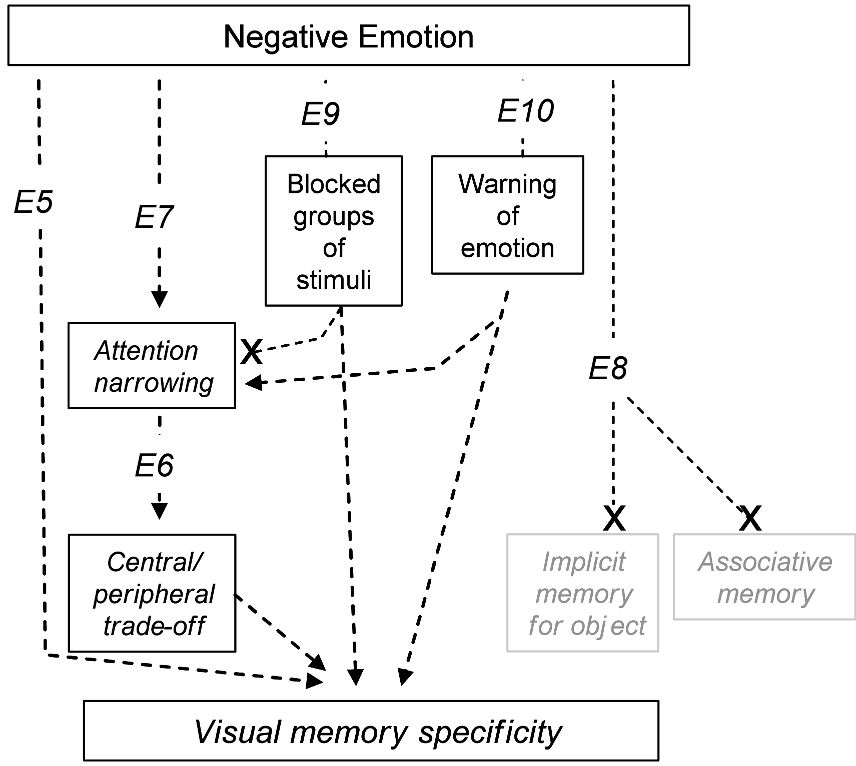


Figure 6.3 Summary of findings from Chapters 4 and 5: Negative emotion

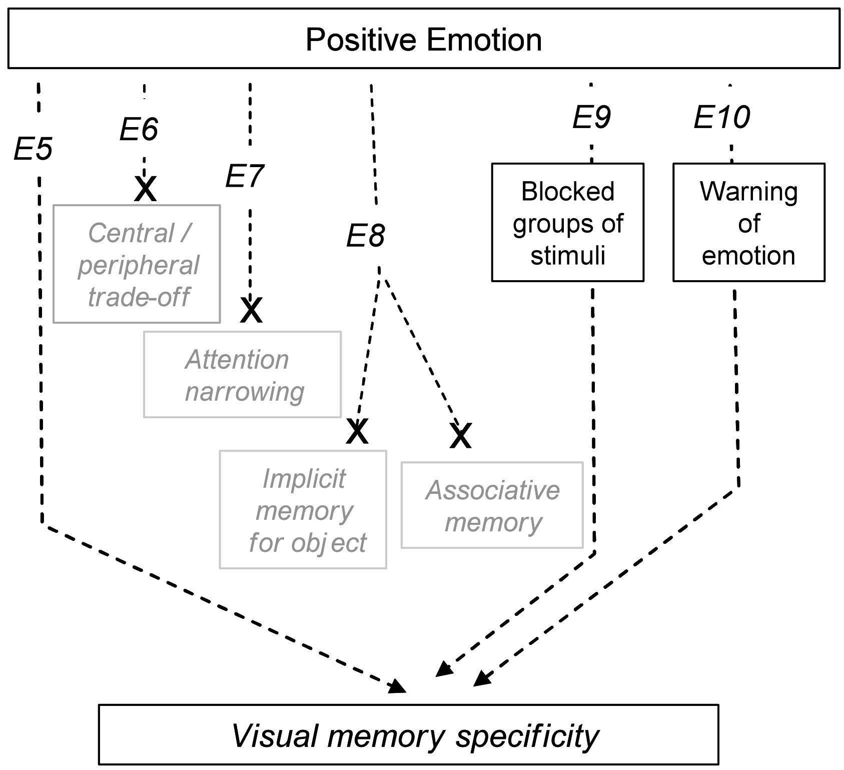


Figure 6.4 Summary of findings from Chapters 4 and 5: Positive emotion

Section 6.2. Ideas for further research

The research conducted in this thesis has led to some interesting findings for which there are several worthwhile avenues of further investigation. However, the critical question in this thesis that remains unanswered is how the negative and positive emotional enhancement of visual specificity of memory can be explained. In the introduction to this thesis two theories were described of how emotion may influence the encoding process of memory and through this lead to the emotional enhancement of memory. In the first theory it was argued that emotion alters the allocation and distribution of attention to an event (e.g. Christianson, 1992). In the second theory it was argued that emotional events are relatively rare or unusual and this enhanced distinctiveness of emotional events may lead to the enhancement of memory (e.g. Schmidt, 2002). This first theory suggests that the experience of emotion alters cognitive processes whereas the second theory suggests that some associated characteristic of emotional events leads to the emotional enhancement of memory. In this thesis I have examined the influence of emotion that has been described in both of these theories but the findings do not provide clear support for either of these theoretical explanations of an emotional enhancement of memory. One thing that is clear is the complexity of the relationship between emotion and memory and the likelihood that some aspects of both of the theories above impact upon this relationship. Some additional experiments which could provide further evidence in support of either of these theoretical explanations are described below.

We found no firm evidence of a causal relationship between the narrowing of visual spatial attention and memory for specific details, however, alternative measures of attention have been used to show a causal relationship with emotional enhancement of memory. Talmi et al (2007) found that a positive emotional enhancement of recognition memory was mediated by attention by asking participants to perform a concurrent auditory discrimination task at the time of encoding stimuli. With negative emotional stimuli there were no effects on subsequent recognition as a result of dividing attention at the time of encoding. This experiment did not examine memory for central or peripheral elements separately and did not examine memory for specific visual details so the effects of a divided attention task on recognition with the Same / Similar / New paradigm are not clear. By considering the impact of dividing attention at the time of encoding on the Same / Similar / New paradigm it might be possible to draw conclusions about a causal relationship between attention and the emotional enhancement of visual memory specificity.

One finding from this thesis that stands out is the different effects on memory and attention from positive emotion than negative emotion. This leads to the question of whether these differences are due to the emotion or some other aspect of the stimuli which is different? One possibility is that many of the positive stimuli become emotional as a result of a semantic and personal interpretations of the stimuli, for example a birthday cake may be positive emotionally because it brings to mind happy experiences of birthday parties. Whereas, in contrast many of the negative stimuli are generically negative, for example the threat of a weapon could be experienced in the same way by all participants. This concept of the self-relevance of information has been shown to influence memory (Gutchess, Kensinger, Yoon & Schacter, 2007) and could be one of the ways in which positive emotional stimuli differ from negative stimuli. One way to answer the question of whether the differences with positive emotion are due to the stimuli or the emotion could be to assess memory just for neutral stimuli using the Same / Similar / New paradigm but induce a positive, negative, or neutral mood in participants and compare memory performance whilst participants are in different moods. In this way the influence of emotion on memory for specific visual details could be examined whilst keeping the characteristics of the stimuli consistent.

In this thesis distinctiveness of stimuli was manipulated by presenting stimuli in mixed or blocked lists of emotion. However, emotional stimuli may also be distinctive in terms of the contrast in the memory representation between distinctive and common information (see Schmidt & Saari, 2007). The memory representations of emotional items may stand out against the background of memory representations for neutral items. In this case item distinctiveness would have an effect at retrieval and not at encoding. If this were the case we would expect any manipulation of item distinctiveness at encoding by blocking stimuli to have no effect on the emotional enhancement of memory. This could be examined directly by conducting a within-participants manipulation of blocked or mixed lists of emotional stimuli. To allow for sufficient numbers of stimuli the experiment could be conducted on memory for objects presented in isolation, rather than on a contextual background.

Another avenue of further investigation would be to consider the independent influence of emotional arousal, rather than the emphasis on emotional valence that there has been in this thesis. Future research could consider whether the influence of negative and positive emotion on the spatial distribution of visual attention remains the same when levels of lower and higher arousal are compared. This was not possible in the Same / Similar / New experimental paradigm used here due to the constraints placed on selection of stimuli by the necessity of creating congruent negative, neutral and positive versions of each scene. Future experiments could limit the stimuli to negative and positive only which would allow investigation of emotional arousal levels.

In the field of cognition and emotion a large amount of research has been devoted to investigating how individual differences mediate the influence of emotion on cognition. One particular example is the investigation of how people with different levels of anxiety demonstrate different attentional biases. In a meta-analytic review Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijendoorn (2007) concluded that although a threat-related bias is a robust phenomenon in anxious individuals, it does not exist in nonanxious individuals. This indicates that individual differences could have important implications for the study of attentional biases in relation to emotional enhancement of memory, as it may be that only a sub-group of participants are experiencing the attentional biases for which we might find evidence. In addition the importance of individual differences suggests implications for the elicitation of emotions in participants by the emotional stimuli used in this research. In this thesis a range of items were used for negative and positive stimuli which should have meant that on average participants found the stimuli, as a group, elicited the intended emotions. However, by controlling for individual differences in participants' emotional reactions to stimuli it may be possible to reveal further insights into the relationship between emotion and memory and reduce levels of noise in the data. These ideas discussed above may also help in finding an explanation for the enhancement of memory by negative and positive emotion.

Section 6.3. Emotion and experimental stimuli

In the introduction of this thesis different ways of defining emotion and the most appropriate criteria for defining emotion for the investigation of cognitive processes were discussed.

Emotion has been defined in this thesis according to the opposing dimensions of negative and positive valence. This has proved a valuable approach with different effects on memory and attention from stimuli with different valences. Discrete emotions such as sadness, threat, anger have also been described as important to consider (e.g. Levine & Pizarro, 2006) and it may be that further insight into the influence of emotion on cognition could be gained by examining these discrete emotions. The categorisation of photographs from the International Affective Photograph System into discrete negative emotions of fear, disgust, sadness and anger has been conducted, although one of the difficulties can be that the majority of emotions are a blend of more than one of these basic emotions (Mikels et al., 2005). This blending of different emotions can cause difficulty in interpreting the findings but would be an avenue of research worth pursuing.

In the first two chapters of this thesis I used photographs from the International Affective Picture System (Lang et al, 2001) as experimental stimuli. These IAPS photographs have been used extensively in emotion and cognition research. They are a very large source of easily accessible emotional and non-emotional photographical stimuli. However, through my experience of designing and conducting experiments with the IAPS I have come across several difficulties in using these stimuli to investigate cognitive processes. There are perceptual differences in the characteristics of negative, neutral and positive emotionally arousing stimuli from this source. These differences include: the negative photographs tend to be darker, the positive photographs tend to be of bolder colours and the neutral photographs tend to be less complex as they often depict a single object on a relatively plain background. I attempted to select stimuli in a way that would minimise these differences and in chapter 3 adjusted the levels of colour saturation to obtain similarity across positive, negative and neutral groups of stimuli.

Another difficulty in using the IAPS as a stimulus source is that by controlling for the perceptual characteristics described it is very likely that the final experimental set will be a mix of objects, animals, people and faces. Research indicates that there may be specialised cognitive processes for recognising human faces and interpreting emotions from facial expressions (Adolphs, 2002) and therefore ideally, this could be controlled by either exclusively using faces in emotional stimuli, excluding faces altogether or specifically including them as a factor. An additional difficulty with the IAPS is that some of the photographs are extracted from film stills or advertising shots and may be very well known to some participants in the experiment, introducing the problem that for some participants the study phase of the experiment does not involve encoding of novel stimuli. The elicitation of emotions by some of the pictures (for example American football games) may depend on cultural relevance and as many of the pictures appear to be North

American this can lead to difficulties in conducting experiments with groups of participants who may not be aware of these cultural references.

The differentiation of memory for central and peripheral elements of a stimulus can provide great insights into memory processes but these type of experiments are very difficult with the IAPS stimuli. Many negative photographs may contain several objects or people in the context of a complex scene, for example a scene of destruction and civil war, whereas positive and neutral photographs may be more likely to contain just one item e.g. a close up image of one person’s face or a single object such as a rolling pin on the plain background of a table. These differences can have important implications for the objective definition of central and peripheral elements in a picture.

For many of the reasons described above I decided to explore the use of a different type of stimuli to elicit emotions. In creating my own set of stimuli similar to those described by Kensinger et al. (2006) it was possible to minimise many of the problems described above. Namely, the stimuli excluded any people or faces and each stimulus contained a background and single object. By creating negative, neutral and positive versions of each scene with the same neutral background the difficulties with IAPS pictures of different backgrounds in photographs of different emotional valence were avoided. There were some difficulties in creating the stimulus set of 72 scenes with a negative, neutral and positive version of each. One of these difficulties was in finding 72 plain backgrounds which could be uniquely described and provided semantically congruent backgrounds for the negative, neutral and positive objects pairs which had been used in the previous experiment. The constraints in selection of objects, with the exclusion of faces and people unfortunately contributed to the difficulty in creating a set of negative arousing and positive arousing stimuli, and the level of emotional arousal was rated as much lower for the positive objects than negative objects. In the IAPS the majority of the positive arousing stimuli set include faces, people winning or playing exhilarating sports or erotic images, none of which were included in the stimulus set that I created. The overall distribution of emotional valence and arousal of stimuli used in Experiment 5 is shown below to indicate this point (See Figure 6.5). This shows the overlap in ratings of arousal for the neutral and positive stimuli. This distribution of emotional arousal in the stimuli used has prevented me from being able to make any strong conclusions about the specific contribution of emotional valence or arousal to the different findings with positive emotion.

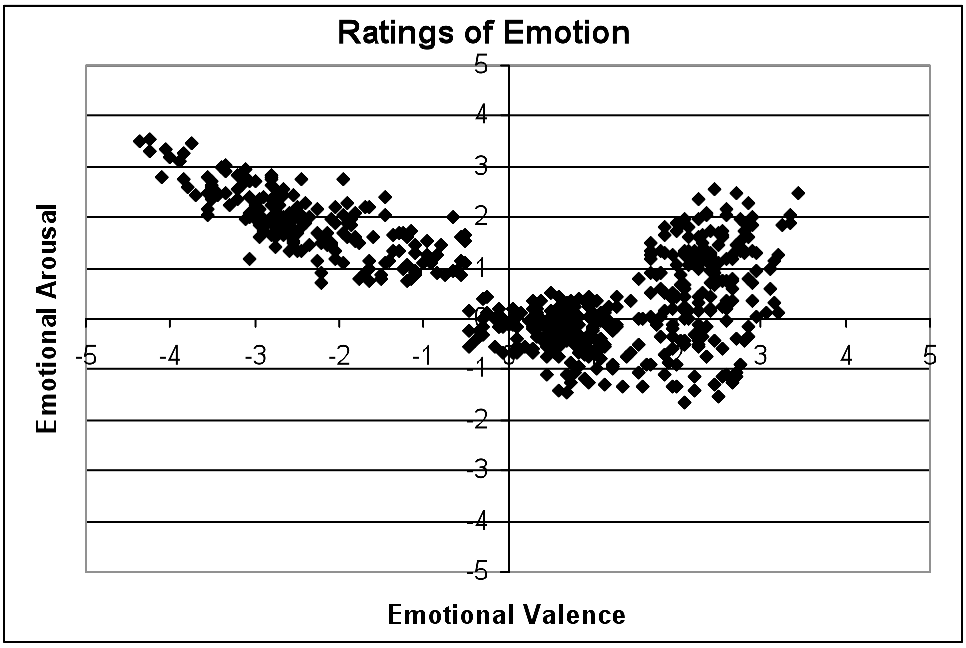


Figure 6.5. Average ratings of emotional arousal and valence (scale -5 to +5) given for negative, neutral and positive objects used in Experiment 5

The nature of individual differences in the elicitation of emotions through the use of photographic stimuli, in particular, became apparent when considering the ratings given by individuals. For example, the mean average rating of high negative arousal and valence of some pictures may have been due to ratings from only a subset of the participants who rated the pictures. As discussed further below one possible way of overcoming this would be to use personalised stimuli to elicit emotions in different participants. The average ratings for emotional valence and arousal given to photographs presented in a mixed list of negative and neutral stimuli (for Experiment 4) were often different than those given to photographs presented in a mixed list of positive, negative and neutral stimuli (for Experiment 5). This may indicate that the ratings given for stimuli in this way reflect feelings of emotion relative to other stimuli rated, rather than experiences of emotion in the real world or it may indicate individual differences between participants rating photographs. It is not clear whether feelings of emotion experienced in real life would be tempered by other experiences close in time or whether the emotions experienced are independent of other surrounding events.

One difficulty in using photographic stimuli to induce emotions was apparent in the use of both the IAPS and the stimulus set that I created for the Same/Similar/New paradigm. Pictorial stimuli to evoke negative emotion are often over-reliant on weapons, positive emotions over-reliant on foods and cute animals and neutral stimuli on obscure or everyday household or office objects. This leaves unresolved the question of whether the differences found between positive and negative stimuli are due to the emotions evoked by these stimuli, the perceptual or semantic characteristics of items shown in the stimuli or whether these perceptual differences are genuinely reflective of real-world differences in emotional events.

The implications of all of the issues discussed above with regards to the study of emotion depend on how emotion is defined. In the introduction I described some different frameworks that have been used to study emotion; emotions are biologically given, emotions are socially constructed, emotions are the result of perception of bodily changes, emotions are the result of cognitive appraisals. In this thesis I think that the use of photographic stimuli to elicit emotions assumes that emotions are both social constructs and the result of cognitive appraisals. Although I have not examined any neural or physiological reactions to emotion in this thesis I would also argue that biological reactions to emotional stimuli have an important role to play in the manner in which emotion affects cognitive processes.

Section 6.4. Task instructions and experimental paradigm

In the field of cognition and emotion there are many inconsistencies in research findings as described in the introduction. Some of these inconsistencies may be due to the experimental paradigms used. Different paradigms may reveal different relationships between memory and emotion and it is not always clear if these are important general differences or specific to one particular experimental paradigm. Some of the inconsistencies of findings between different paradigms may be due to performance in different tasks being based on different types of memory or memory for different parts of an experimental stimulus or emotional event. It is also possible that some tasks may lead to more consistent performance across participants than other tasks, one reason for this may be the level of clarity in task instructions given to participants.

In the first experimental chapter of this thesis I examined the level of recognition memory for emotional and non-emotional stimuli when different retrieval strategies were induced through different task instructions. These series of experiments were adapted from an existing paradigm (Whittlesea & Price, 2001), however, after conducting research using this paradigm the ambiguity and lack of clarity in some of the task instructions became apparent. Specifically, the instructions for the analytic retrieval condition relied on attempted deception of participants in that they were instructed to identify in a two-alternative forced choice recognition test the stimulus which had been changed from the earlier presentation. In reality, none of the photographs had been changed and it is possible that participants were confused by the instructions. Indeed this may be part of the reason that their performance on this task was at chance. As a result of these concerns I was very keen to move to an experimental paradigm with very clear task instructions for participants which should ensure that all participants completed the task as intended.

In using the Same / Similar / New paradigm (Kensinger et al., 2006) in this thesis we have consistently found the same pattern of emotional enhancement and impairment in memory across a series of experiments. This suggests the use of such a well-controlled paradigm is effective in reducing inconsistencies when assessing memory for central and peripheral elements of stimuli. The lack of ambiguity in instructions to participants in the Same / Similar / New paradigm is also apparent when comparing this to the Remember / Know / New paradigm. The standard instructions for this paradigm (e.g. Gardiner &

Richardson-Klavehn, 2005) with the distinction between Remembering and Knowing may make sense to participants if Tulving's (1985) memory model is assumed to be true and there are two different forms of memory. However, many researchers now argue for a single-process model of memory (e.g. Donaldson, 1996) and in that case RKN responses may relate to participants confidence in memory. The ambiguity and individual differences in participants' interpretation of task instructions is reduced with the Same / Similar / New paradigm and the remarkably consistent results that I have found with this paradigm across a series of experiments with small changes in the methodology highlights the robustness of findings with this paradigm.

One potential concern in the conclusions that can be drawn from the Same / Similar / New paradigm is what aspect of specificity of memory for emotional and neutral items the paradigm is really measuring. I have assumed, as did Kensinger et al. (2006, 2007a, 2007b) that this is based on memory for visual details of the stimuli, however, it is possible that participants might be basing their decision to classify an item as Same / Similar / new on alternative information. One way to clarify this could be to conduct an experiment explicitly examining memory for visual details and see if the same pattern of results is found. For example, a change detection paradigm could be used where participants need to identify a small change in detail is made to the object or background of a scene.

A possible limitation of the Same / Similar / New paradigm is that following Kensinger et al. (2006) the analysis is restricted to items that were the same at the time of study and test. This means that although participants are presented with a reasonably large number of stimuli during the study and test phase, only a small proportion of this data is used. It may be interesting to consider what insights might be gained by examining memory for the similar items. One of the reasons, and that given by Kensinger, for the difficulty in interpreting responses to the similar items is that it is not known whether participants give a similar response to indicate that they remember the specific visual details of the related item from the study phase and therefore they can say this is not that item, or to indicate they have a vague memory of an item of that type but no memory for the visual details and therefore cannot be sure whether this item or a related item was presented. In addition to this, a difficulty with the similar items is that the extent to which they differ from the 'same' item varies. For example, one similar item may be different in orientation and colour to the same item, but otherwise it is identical. Alternatively, one similar item may differ because it is actually a different object although it is of the same type (e.g. another type of skull). This could have lead to inconsistencies in how participants selected a 'similar' response and means it is not clear which is the correct response when presented with a similar item.

One other possible limitation of the Same / Similar / New paradigm is the difficulty of examining false alarm rates. I have chosen to limit analysis of false alarms to keep it similar to that conducted by Kensinger et al. (2006, 2007a, 2007b). Therefore, I examined the responses given to New items to examine any potential response bias to emotional items (particularly positive items which have been shown to be susceptible to response bias) and found no evidence for response bias. False alarm rates could be considered by using a mathematical model such as variants on Signal Detection Theory or Single

High Threshold Theory (Macmillan & Creelman, 1990). However, it is not immediately obvious which mathematical model should be applied to the SSN task and the choice of model would affect the results obtained.

Section 6.5. Encoding or Retrieval effects

In this thesis I have examined the effects of emotion on processes occurring at the time of encoding or retrieving a memory. From this research it is not possible to definitively conclude whether encoding or retrieval effects are critical to the emotional enhancement of memory. Nevertheless, findings that emotional enhancement of visual specificity of memory cannot solely be accounted for by effects of visual attention at encoding suggest that is it likely that emotion has influences on additional processes. In speculating what these might be I would suggest emotion may exert an influence on processes of encoding and retrieval, even though perhaps stronger effects on memory may be seen with encoding than retrieval effects.

Despite the intended focus of experiments in this thesis on encoding and retrieval effects it is also possible that emotions may exert an effect during the process of consolidating a memory (e.g. Soetens et al., 1995). In the experimental findings of this thesis it is difficult to distinguish between whether these effects are due to encoding, consolidation or retrieval effects. For example, the central-peripheral trade-off effects in memory for negative emotional stimuli may be due to encoding, consolidation or retrieval. After Experiment 7 I seemed to have found concrete evidence for attentional effects at the time of encoding negative emotional stimuli that were associated with the central-peripheral trade-offs in memory for these stimuli, even though causation could not be implied. However, the findings of Experiment 9 where the blocking of stimuli into emotional groups removed evidence of attentional narrowing at the time of encoding whilst the central-peripheral trade-off in memory remained, opens up the possibility of these memory effects being due to the influence of emotion on processes at either encoding, consolidation or retrieval. It is possible that blocking stimuli by emotion could lead to mood effects as the block progresses which may affect the consolidation of memories for the stimuli that are presented later in a block. Another possibility is that memory for the association between the object and background could provide a cue at the time of retrieval, which may be interpreted differently depending on whether the object is negative, neutral or positive. It is also possible that emotional experiences may be induced at the time of encoding and retrieving memories as participants are exposed to emotional stimuli at both of these times.

Section 6.6. Relating these findings to the real world

In this thesis different experimental paradigms have been used to investigate memory but the method of inducing emotional experiences has been constant throughout. This has been through the presentation of photographs of complex scenes which have been rated as inducing negative, neutral or positive emotions. This is an effective method to use for investigating memory as it allows for precise control over the visual information presented to participants which is then used for the memory test. One of the limitations of this method of emotional induction is that not all the emotional stimuli may produce the same level of emotional reaction in each participant and the artificial production of emotions may make them qualitatively different to emotions experienced in real life events. One way to overcome this limitation could be to induce emotions by asking participants to recall emotional events from their own life (e.g. Berntsen, 2002). This would ensure that the emotions are ecologically valid, however, with this type of emotion induction it can be difficult to quantify the emotions experienced by different participants and ensure participants experience similar emotions.

One other limitation of research in this thesis could be from the study of experimentally produced memories. It is possible that memories of autobiographical life events are affected in a different way by emotion than the artificial stimuli used in this thesis, although, this artificiality was limited by the use of photographs of complex everyday visual scenes, in comparison to the abstract stimuli used in some research. Similar to the limitations of using individual experiences to elicit emotion, with autobiographical memories it can be difficult to differentiate between differences in the actual life events experienced as opposed to participants' memories of these events. Nevertheless, the examination of autobiographical memories of negative and positive life events has led to a pattern of findings of reduced memory for peripheral aspects of a negative life event (e.g. Talarico et al, 2009) that is similar to the findings of a central-peripheral trade-off with negative experimental stimuli.

The paradigms used in this thesis have been artificial experimental representations of how emotion may effect memory for actual life events, nevertheless, the findings may still apply to real world experiences. For example, the finding of negative and positive emotional enhancement of memory for specific visual details when stimuli are blocked into groups could suggest that either a negative or a positive mood may lead to a more fine-grained memory for events. Therefore, if a person wants to ensure they remember the details of an event it may be important to be experiencing some type of emotional mood that differs from neutral, regardless of the particular direction of this mood.

Section 6.7. Final Conclusion

In conclusion, the main findings of this thesis are of an enhancement of memory for specific visual details by both negative and positive emotion with an accompanying impairment to memory for peripheral details only with negative emotion. I found that at the time of encoding a stimulus into memory the narrowing of spatial visual attention onto the source of emotion in a scene with a negative object is often associated with, but not necessarily causal of, negative emotional trade-offs in memory. I have also found that the emotional enhancement of memory by both positive and negative emotion can be found even without obvious visual biases in attention at the time of encoding. This suggests that other cognitive processes at the time of encoding, consolidating or retrieving memories may be affected by emotion and contribute to the emotional enhancement of memory.

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Appendix 2.1. IAPS numbers for the picture stimuli

Positive pictures list A: 1419, 1440, 1590, 1601, 1720, 1722, 1750, 1811, 2050, 2080, 2092, 2352, 2510, 5270, 5450, 5626, 5890, 7230, 7250, 7390, 7502, 8116, 8161, 8162, 8190, 8220, 8380, 8490, 8496, 8503

Positive pictures list B: 1460, 1500, 1540, 1620, 1650, 1710, 1740, 1810, 1920, 2209, 2655, 5300, 5460, 5480, 5600, 5623, 5629, 5849, 5994, 7195, 7325, 7580, 8021, 8041, 8090, 8180, 8200, 8210, 8260, 8531

Neutral pictures list A: 1112, 1121, 1321, 1726, 1931, 1945, 1947, 2220, 2372, 2441, 2487, 2690, 2702, 3550, 4274, 5395, 5532, 5535, 5661, 6000, 6900, 7037, 7496, 7503, 7550, 7590, 7640, 8211, 9472, 9913

Neutral pictures list B: 1230, 1303, 1310, 1313, 1616, 1935, 2272, 2410, 2575, 2595, 2635, 2695, 2749, 2780, 5920, 7095, 7096, 7402, 7504, 7600, 7620, 7830, 7920, 8160, 8232, 8475, 9080, 9171, 9401, 9411

Negative pictures list A: 1220, 2120, 2141, 2205, 2312, 2455, 2590, 2800, 3220, 3280, 6010, 6200, 6211, 6312, 6571, 6940, 7360, 9001, 9101, 9120, 9290, 9320, 9390, 9415, 9480, 9561, 9592, 9621, 9830, 9910

Negative pictures list B: 1090, 1274, 2490, 2692, 2700, 2710, 2715, 3022, 6213, 6838, 8230, 8480, 9000, 9010, 9042, 9090, 9190, 9280, 9331, 9373, 9400, 9404, 9430, 9470, 9471, 9520, 9530, 9560, 9600, 9611

Appendix 2.2. ANOVA Analyses for Experiment 1E: RKG responses

Table 2.2.1. Experiment 1E: Results of separate ANOVA analysis on Remember/Know/Guess responses

	Remember	Know	Guess
Emotion block	$F_{(2,22)} = 0.44$, MSe = 0.79, p = .65	**$F_{(2,22)} = 3.81$, MSe = 4.51, p < .05**	$F_{(2,22)} = 1.49$, MSe = 2.95, p = .25
Repetitions	**$F_{(2,22)} = 7.82$, MSe = 1.85, p < .01**	$F_{(2,22)} = 0.19$, MSe = 0.06, p = .83	**$F_{(2,22)} = 5.34$, MSe = 2.56, p <0.05**
Accuracy	$F_{(1,11)} = 2.96$, MSe = 3.13, p = .11	$F_{(1,11)} = 0.85$, MSe = 0.78, p = .38	$F_{(1,11)} = 0.28$, MSe = 1.34, p = .61
Emotion block*Repetitions	$F_{(4,44)} = 0.55$, MSe = 0.35, p = .70	$F_{(4,44)} = 1.19$, MSe = 0.80, p = .33	$F_{(4,44)} = 1.75$, MSe = 1.99, p = .16
Emotion block*Accuracy	$F_{(2,22)} = 0.52$, MSe = 0.17, p = .60	$F_{(2,22)} = 0.64$, MSe = 0.78, p = .54	$F_{(2,22)} = 0.46$, MSe = 1.67, p = .64
Repetitions*Accuracy	$F_{(2,22)} = 2.60$, MSe = 2.51, p = .10	$F_{(2,22)} = 0.39$, MSe = 0.48, p = .68	$F_{(2,22)} = 0.08$, MSe = 0.23, p = .92
Emotion*Repetitions*Accuracy	$F_{(4,44)} = 1.31$, MSe = 0.46, p = .28	$F_{(4,44)} = 1.58$, MSe = 1.60, p = .20	$F_{(4,44)} = 0.59$, MSe = 1.77, p = .67

Table 2.2.2. Experiment 1: Probabilities of Hits or False Alarms to a Remember / Know / Guess judgement, Recollection and Familiarity in a two alternative forced-choice test (by number of training presentations)

Number of	Remember		Know		Guess		Rec	Fd'
Repetitions	Hits	FAs	Hits	FAs	Hits	FAs		
One	.06	.05	.15	.15	.32	.31	.01	-.11
Three	.06	.07	.17	.13	.30	.29	-.01	-.30
Five	.12	.05	.16	.15	.29	.26	.06	-.52

NB: Rec = Recollection; Fd' = Familiarity – both calculated according to Yonelinas et al (1998)

Table 2.2.3. Experiment 1: Probabilities of Hits or False Alarms to a Remember / Know / Guess judgement, Recollection and Familiarity in a two alternative forced-choice test (by emotion block)

Emotion	Remember		Know		Guess		Rec	Fd'
Block	Hits	FAs	Hits	FAs	Hits	FAs		
Positive	.07	.04	.20	.16	.30	.26	.03	-.24
Neutral	.08	.07	.15	.15	.30	.30	.01	-.40
Negative	.08	.06	.13	.12	.31	.33	.02	-.26

NB: Rec = Recollection; Fd' = Familiarity – both calculated according to Yonelinas et al (1998)

Table 2.2.4. Experiment 1: Separate ANOVA analysis on Recollection and Familiarity

	Recollection	Familiarity
Emotion block	$F_{(1.2,12.8)} = 0.63$, MSe = 0.01, $p = .54$	$F_{(2,22)} = 0.11$, MSe = 0.13, $p = .90$
Repetitions	$F_{(2,22)} = 1.95$, MSe = 0.06, $p = .17$	$F_{(2,22)} = 0.42$, MSe = 0.54, $p = .66$
Emotion block*Repetitions	$F_{(4,44)} = 1.48$, MSe = 0.01, $p = .23$	$F_{(4,44)} = 1.97$, MSe = 1.47, $p = .12$

Appendix 3.1

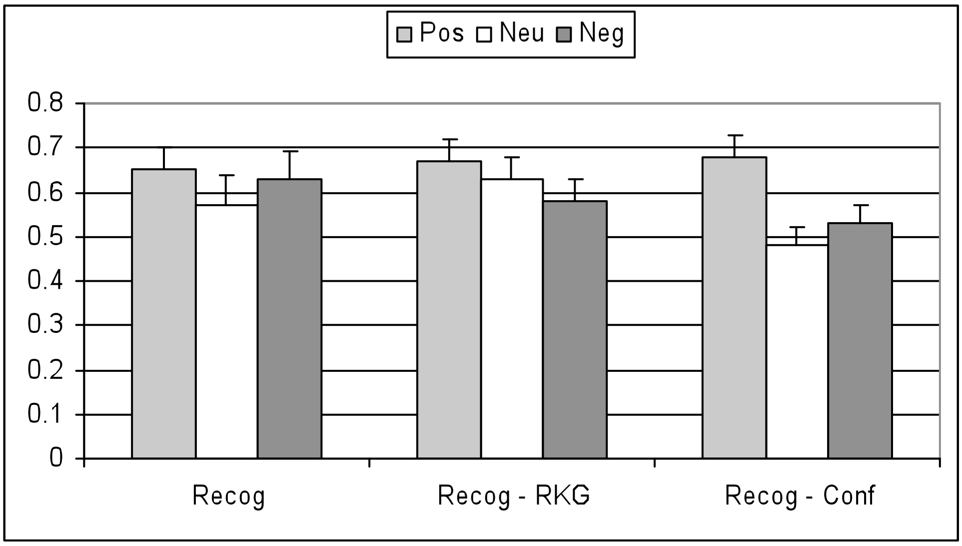
Table 3.1. Low-level visual properties of photos presented as Study List A or Study List B: Positive Emotion block photos

	Negative		Neutral		Positive	
Study list	A	B	A	B	A	B
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Valence	2.99 (0.58)	3.09 (0.52)	4.99 (0.61)	5.03 (0.60)	7.19 (0.57)	7.15 (0.50)
Arousal	5.15 (0.73)	5.14 (0.74)	4.72 (0.87)	4.68 (0.84)	5.12 (0.78)	5.09 (0.84)
Luminosity	95.73 (33.89)	95.67 (38.91)	96.22 (34.52)	92.44 (28.67)	90.70 (36.74)	85.30 (29.34)
Complexity	38.27 (9.36)	41.07 (12.23)	42.37 (10.40)	44.73 (15.01)	36.80 (8.89)	41.63 (11.75)
RMS Contrast	1.46 (0.56)	1.43 (0.60)	2.03 (2.75)	1.44 (0.55)	1.49 (0.91)	1.44 (0.49)
Red channel saturation	107.96 (39.76)	106.89 (41.08)	105.20 (40.03)	105.32 (38.13)	105.53 (37.36)	94.57 (30.80)
Green channel saturation	91.80 (33.30)	97.91 (37.55)	93.61 (36.69)	89.10 (27.36)	86.49 (39.64)	82.54 (31.01)
Blue channel saturation	83.67 (33.28)	85.83 (34.70)	85.78 (46.64)	75.29 (33.00)	72.87 (43.46)	74.93 (39.00)

Appendix 3.2. Contamination of Retrieval Style between Tasks

Possible contamination of retrieval style between tasks was examined by comparing recognition performance across only for the task which was performed first so performance could not be contaminated by a different retrieval style from preceding tasks (See Figure 3.2.1).

Figure 3.2.1. Recognition performance across task and emotion only in first task (between groups comparison; N=12 for each task)



The influence of emotion on recognition performance as part of the three different retrieval conditions was analysed by conducting an ANOVA which included data only for those participants who completed the task as the first task block in the experiment. A 3 x 3 ANOVA was conducted with the repeated measures factor of emotion and between participants factor of task. There was a significant main effect of emotion ($F_{(2,66)} = 3.19$, MSE = 11.79, $p < .05$, *partial eta*$^2 = .09$). The main effect of task was not significant [$F_{(2,33)} =$

1.66, MSE = 1.32, $p < .21$, *partial eta*^{2} = .09] and neither was the interaction between emotion and task type [$F_{(4,66)} = 0.76$, MSE = 2.82, $p < .55$, *partial eta*^{2} = .04]. Planned contrasts of the main effect of emotion revealed no significant difference in the recognition of neutral and emotional items [$F_{(1,33)} = 2.87$, p = .10]. There was greater recognition of positive than negative items which was approaching significance [$F_{(1,33)} = 3.50$, $p = .07$].

Planned contrasts were also conducted on each of the recognition tasks separately. This revealed that for the task of straightforward recognition there was no significant difference between for recognition of emotional and neutral items [$F_{(1,11)} = 0.76$, $p = .40$] nor between positive and negative items [$F_{(1,11)}$ = 0.07, $p = .80$]. For recognition followed by a confidence judgement there was significantly greater recognition for emotional than neutral items ($F_{(1,11)} = 7.05$, $p < .05$) and significantly greater recognition of positive than negative items ($F_{(1,11)} = 7.05$, $p < .05$). For recognition followed by a RKN judgement there was no significant difference between for recognition of emotional and neutral items [$F_{(1,11)} = 0.01$, $p = .95$] nor between positive and negative items [$F_{(1,11)}$ = 1.08, $p = .32$].

The pattern of results found when analyzing the first block only is different from that when analyzing performance across all three blocks. However, the null effects of the ANOVA analysis must be interpreted with caution as the variances are greater due to the small number of participants in each between participants group (12).

Appendix 4.1

Analysis of Same, Similar and New responses to Same, Similar, New items

Section 4.1.1 Analysis for Experiment 6

The influence of emotion and scene component on the responses given to *same*, *similar* and *new* items was analysed by conducting separate ANOVAs on each of the different types of items for each experiment. The results from the three 3 (emotion) x 2 (scene component) x 3 (response type) repeated measures ANOVAs are reported below in Tables 4.1.1 and 4.1.2. Significant results are indicated in bold type. The same analysis is reported for Experiments 7, 8, 9 & 10 in Appendices 4.1 and 5.1.

In summary, the emotional influence on memory for specific details is shown by the greater number of 'same' responses to *same* items for emotional than neutral objects. The central-peripheral trade-off in memory is shown by the reduced number of 'same' responses to *same* items for backgrounds which were initially presented with negative than positive objects. There is some indication of an emotional influence on responses to *similar* items but responses to these items are difficult to interpret because correct responses may indicate either visual specificity of memory when participants recognise that they saw an item of that type before know that it was not that exact stimulus, or they may recognise that they saw an item of that type before but remember whether or not it was that exact stimulus. The lack of emotional influence on the responses to *new* items provides evidence that the results of emotional enhancement of visual specificity of memory are due to accuracy of memory, rather than a bias to give a recognition response to emotional stimuli.

Table 4.1.1. Results of ANOVAs on *Same*, *Similar* and *New* items

Same items	
Effect	ANOVA result
Response type	$\boldsymbol{F_{(1.29,21.89)} = 52.13}$**, MSe = 5.97,** $\boldsymbol{p < .001, \eta_p^2 = .75}$
	Tukey's post hoc: Same > Similar, Same > New (q = 12.97, 11.98, p <.001 all cases, respectively)
Scene component* Response type	$\boldsymbol{F_{(1.35,22.99)} = 49.76}$**, MSe = 3.74,** $\boldsymbol{p < .001, \eta_p^2 = .75}$
	Tukey's post hoc: For objects Same > Similar, Same > New (q = 15.23, 16.14, p <.001 all cases, respectively)
Emotion* Response type	$F_{(4,68)} = 0.68$, MSe = 0.02, $p = .61$, $\eta_p^2 = .04$
Scene component* emotion* response type	$\boldsymbol{F_{(4,68)} = 4.28}$**, MSe = 0.14,** $\boldsymbol{p < .01, \eta_p^2 = .20}$
	See Planned contrasts for further analysis
Similar items	
Response type	$F_{(1.50,25.53)} = 3.21$, MSe = 0.56, $p = .05$, $\eta_p^2 = .16$
Scene component* Response type	$\boldsymbol{F_{(1.81,30.70)} = 20.05}$**, MSe = 1.77,** $\boldsymbol{p < .001, \eta_p^2 = .54}$
	Tukey's post hoc: For objects Similar > New, for backgrounds New > Same (q = 4.53, 5.21, p <.01 all cases, respectively)
Emotion* Response type	$F_{(4,68)} = 0.72$, MSe = 0.02, $p = .58$, $\eta_p^2 = .04$

Scene component* emotion* response type	$F_{(4,68)} = 1.92$, MSe = 0.09, $p = .12$, $\eta_p^2 = .10$
New items	
Response type	**$F_{(2,34)} = 147.56$, MSe = 13.10, $p < .001$, $\eta_p^2 = .90$**
	Tukey's post hoc: New > Same, New > Similar (q = 22.51, 19.10, p <.001 all cases, respectively)
Scene component* Response type	**$F_{(1.33,22.54)} = 10.59$, MSe = 0.53, $p < .001$, $\eta_p^2 = .38$**
	Tukey's post hoc: For objects and backgrounds New > Same, New > Similar (Objects: q = 18.96, 16.48, backgrounds: q = 12.88, 10.53, $p < .001$ all cases, respectively)
Emotion* Response type	$F_{(4,68)} = 0.09$, MSe < 0.01, $p = .99$, $\eta_p^2 = .01$
Scene component* emotion* response type	$F_{(4,68)} = 0.40$, MSe = 0.01, $p = .81$, $\eta_p^2 = .02$

Table 4.1.2. Experiment 6 – Planned Contrasts

	Background		Object	
	Emotional vs. Neutral	Negative vs. Positive	Emotional vs. Neutral	Negative vs. Positive
SAME items				
Same response	Emo ≈ Neu $F_{(1,17)} = 4.19$, $p = .06$	**Neg < Pos $F_{(1,17)} = 4.86$, $p < .05$**	**Emo > Neu $F_{(1,17)} = 9.70$, $p < .01$**	Neg ≈ Pos $F_{(1,17)} = 0.30$, $p = .59$
Similar	Emo ≈ Neu	Neg ≈ Pos	**Emo > Neu**	Neg ≈ Pos

response	$F_{(1,17)} = 0.62$, $p = .44$	$F_{(1,17)} = 0.36$, $p = .56$	$\boldsymbol{F_{(1,17)} = 6.44}$, $\boldsymbol{p < .05}$	$F_{(1,17)} = 0.28$, $p = .60$
New response	Emo ≈ Neu $F_{(1,17)} = 0.62$, $p = .44$	Neg ≈ Pos $F_{(1,17)} = 3.40$, $p = .08$	Neg ≈ Pos $F_{(1,17)} = 0.94$, $p = .35$	Neg ≈ Pos $F_{(1,17)} = 1.86$, $p = .19$
		SIMILAR items		
Same response	Emo ≈ Neu $F_{(1,17)} = 0.62$, $p = .44$	Neg ≈ Pos $F_{(1,17)} = 0.02$, $p = .88$	Emo ≈ Neu $F_{(1,17)} = 0.99$, $p = .33$	Neg ≈ Pos $F_{(1,17)} < 0.01$, $p = 1.00$
Similar response	**Emo > Neu** $\boldsymbol{F_{(1,17)} = 5.58}$, $\boldsymbol{p < .05}$	Neg ≈ Pos $F_{(1,17)} = 0.86$, $p = .37$	Emo ≈ Neu $F_{(1,17)} = 0.88$, $p = .36$	Neg ≈ Pos $F_{(1,17)} = 1.72$, $p = .21$
New response	Emo ≈ Neu $F_{(1,17)} = 1.99$, $p = .18$	Neg ≈ Pos $F_{(1,17)} = 0.17$, $p = .68$	Emo ≈ Neu $F_{(1,17)} = 4.33$, $p = .05$	Neg ≈ Pos $F_{(1,17)} = 1.52$, $p = .24$
		New items		
Same response	Emo ≈ Neu $F_{(1,17)} = 0.01$, $p = .93$	Neg ≈ Pos $F_{(1,17)} = 0.23$, $p = .64$	Emo ≈ Neu $F_{(1,17)} = 0.04$, $p = .85$	Neg ≈ Pos $F_{(1,17)} = 0.09$, $p = .77$
Similar response	Emo ≈ Neu $F_{(1,17)} = 0.38$, $p = .55$	Neg ≈ Pos $F_{(1,17)} = 0.81$, $p = .38$	Emo ≈ Neu $F_{(1,17)} = 0.01$, $p = .92$	Neg ≈ Pos $F_{(1,17)} = 0.22$, $p = .64$
New response	Emo ≈ Neu $F_{(1,17)} = 0.22$, $p = .65$	Neg ≈ Pos $F_{(1,17)} = 0.21$, $p = .65$	Emo ≈ Neu $F_{(1,17)} < 0.01$, $p = 1.00$	Neg ≈ Pos $F_{(1,17)} = 0.09$, $p = .77$

Section 4.1.2 Analysis for Experiment 7

The influence of emotion and scene component on the responses given to *same*, *similar* and *new* items was analysed by conducting separate ANOVAs on each of the different types of items for each experiment. The results from the three 3 (emotion) x 2 (scene component) x 3 (response type) repeated measures ANOVAs are reported below in Tables 4.1.3 and 4.1.4.

In summary, the emotional influence on recognition of specific visual details was shown by a greater number of 'same' responses to *same* items for emotional than neutral objects. The central-peripheral trade-off was indicated by less 'same' responses to backgrounds that had initially been presented with negative than positive objects, although this finding was only approaching statistical significance. There was no overall emotional influence on responses to *new* items, although planned contrasts revealed that participants were more likely to give a correct 'new' response to *new* positive than negative items, and correspondingly more likely to give a 'similar' response to *new* negative than positive items. This was the only experiment in which any influence of emotion was found on the responses given to *new* items and therefore it seems likely that this is an anomaly in the data as we have no explanation for why there would be a difference in responding to *new* items in this experiment only.

Table 4.1.3. Results of ANOVAs on *Same*, *Similar* and *New* items

Same items	
Effect	ANOVA result
Response type	$\boldsymbol{F_{(1.35,22.99)} = 37.37, \text{MSe} = 5.06, p < .001, \eta_p^2 =}$

	.69
	Tukey's post hoc: Same > Similar, Same > New (q = 10.49, 10.69, p < .001 all cases, respectively)
Scene component* Response type	**$F_{(2,34)}$ = 17.89, MSe = 1.87, p < .001, η_p^2 = .51**
	Tukey's post hoc: For object Same > Similar, Same >New, for background Same > Similar (Object: q = 11.28, 12.57, p < .001 all cases, background: q = 3.56, p < .05, respectively)
Emotion* Response type	$F_{(4,68)}$ = 1.68, MSe = 0.06, p = .17, η_p^2 = .09
Scene component* emotion* response type	**$F_{(4,68)}$ = 2.66, MSe = 0.07, p < .05, η_p^2 = .14**
	See Planned contrasts for further analysis
Similar items	
Response type	**$F_{(1.51,25.70)}$ = 7.23, MSe = 1.09, p < .01, η_p^2 = .30**
	Tukey's post hocs: Similar > Same (q = 5.32, p < .01)
Scene component* Response type	**$F_{(2,34)}$ = 10.38, MSe = 0.81, p < .001, η_p^2 = .38**
	Tukey's post hocs: For objects Similar > Same, Similar > New, for backgrounds Similar > Same, New > Same (Objects: q = 3.94, p < .05; q = 5.25, p < .01, Backgrounds: q = 3.59, 4.16, p < .05).

Emotion* Response type	$F_{(4,68)} = 0.93$, MSe = 0.03, $p = .45$, $\eta_p^2 = .05$
Scene component* emotion* response type	$F_{(4,68)} = 1.74$, MSe = 0.07, $p = .15$, $\eta_p^2 = .09$
New items	
Response type	**$F_{(1.14,19.35)} = 160.58$, MSe = 15.07, $p < .001$, $\eta_p^2 = .90$**
	Tukey's post hocs: New > Same, New > Similar, Similar > Same ($q = 23.95, 19.16, 4.79$, $p < .001, .001, .01$)
Scene component* Response type	**$F_{(1.35,22.98)} = 5.97$, MSe = 0.11, $p < .01$, $\eta_p^2 = .26$**
	Tukey's post hocs: For objects New > Similar, New > Same, Similar > Same and for backgrounds New > Same, New > Similar (Objects: $q = 18.32, 14.82, 3.50$, $p < .001, .001, .05$; Backgrounds: $q = 15.55, 12.27$, $p < .001$)
Emotion* Response type	**$F_{(2.43,41.23)} = 3.10$, MSe = 0.06, $p < .05$, $\eta_p^2 = .15$**
	See planned contrasts for further analysis.
Scene component* emotion* response type	$F_{(2.18,39.97)} = 0.11$, MSe < 0.01, $p = .98$, $\eta_p^2 = .01$

Table 4.1.4. Planned Contrasts

	Background		Object	
	Emotional vs. Neutral	Negative vs. Positive	Emotional vs. Neutral	Negative vs. Positive

SAME items				
Same response	Emo ≈ Neu $F_{(1,17)} = 0.30$, $p = .59$	Neg ≈ Pos $F_{(1,17)} = 3.37$, $p = .08$	**Emo > Neu** $\boldsymbol{F_{(1,17)} = 4.50}$, $\boldsymbol{p < .05}$	Neg ≈ Pos $F_{(1,17)} = 0.25$, $p = .63$
Similar response	Emo ≈ Neu $F_{(1,17)} = 1.24$, $p = .28$	Neg ≈ Pos $F_{(1,17)} = 0.07$, $p = .79$	Emo ≈ Neu $F_{(1,17)} = 1.12$, $p = .31$	Neg ≈ Pos $F_{(1,17)} = 0.41$, $p = .53$
New response	Emo ≈ Neu $F_{(1,17)} = 0.34$, $p = .57$	Neg ≈ Pos $F_{(1,17)} = 4.11$, $p = .06$	Neg ≈ Pos $F_{(1,17)} = 2.92$, $p = .11$	Neg ≈ Pos $F_{(1,17)} = 0.11$, $p = .75$
SIMILAR items				
Same response	Emo ≈ Neu $F_{(1,17)} = 0.10$, $p = .76$	Neg ≈ Pos $F_{(1,17)} = 1.36$, $p = .26$	Emo ≈ Neu $F_{(1,17)} = 0.64$, $p = .44$	Neg ≈ Pos $F_{(1,17)} = 0.22$, $p = 65$
Similar response	Emo ≈ Neu $F_{(1,17)} = 0.57$, $p = .46$	Neg ≈ Pos $F_{(1,17)} = 0.41$, $p = .53$	Emo ≈ Neu $F_{(1,17)} = 3.20$, $p = .09$	Neg ≈ Pos $F_{(1,17)} = 0.93$, $p = .35$
New response	Emo ≈ Neu $F_{(1,17)} = 0.18$, $p = .68$	Neg ≈ Pos $F_{(1,17)} = 0.34$, $p = .57$	**Emo < Neu** $\boldsymbol{F_{(1,17)} = 9.26}$, $\boldsymbol{p < .01}$	Neg ≈ Pos $F_{(1,17)} = 1.00$, $p = .33$
New items				
Same response	Emo ≈ Neu $F_{(1,17)} = 0.02$, $p = .90$	Neg ≈ Pos $F_{(1,17)} = 0.06$, $p = .82$	Emo ≈ Neu $F_{(1,17)} = 0.06$, $p = .81$	Neg ≈ Pos $F_{(1,17)} = 0.14$, $p = .72$
Similar	Emo ≈ Neu	Neg ≈ Pos	Emo ≈ Neu	**Neg > Pos**

response	$F_{(1,17)} = 0.25$, $p = .63$	$F_{(1,17)} = 2.74$, $p = .12$	$F_{(1,17)} = 0.01$, $p = .94$	**$F_{(1,17)} = 4.48$, $p < .05$**
New response	Emo ≈ Neu $F_{(1,17)} = 0.20$, $p = .66$	Neg ≈ Pos $F_{(1,17)} = 1.84$, $p = .19$	Emo ≈ Neu $F_{(1,17)} = 0.03$, $p = .87$	**Neg < Pos $F_{(1,17)} = 4.73$, $p < .05$**

Appendix 5.1. Analysis of Same, Similar, New Responses to Same, Similar, New items

Section 5.1 Analysis for Experiment 8

The influence of emotion and scene component on the responses given to *same*, *similar* and *new* items was analysed by conducting separate ANOVAs on each of the different types of items for each experiment. The results from the three 3 (emotion) x 2 (scene component) x 3 (response type) repeated measures ANOVAs are reported below in Tables 5.1.1 and 5.1.2. Significant results are indicated in bold type. The analysis reported here is the same as that conducted for Experiments 6 & 7 and reported in Appendix 4.1.

In summary, the emotional influence on memory for specific visual details was shown by the greater number of 'same' responses to *same* items for emotional than neutral objects. The central-peripheral trade-off was indicated by few 'same' responses to *same* items for backgrounds that were initially presented with negative than positive objects, although this difference was only approaching statistical significance. As described above in Appendix 4.1, the responses to *similar* items are difficult to interpret. The responses to *new* items indicated no emotional influence on a bias to respond to emotional items as if there was recognition even when there was no recognition present for that item.

Table 5.1.1. Results of ANOVAs on *Same*, *Similar* and *New* items

Same items	
Effect	ANOVA result
Response type	**$F_{(2,34)}$ = 40.45, MSe = 5.46, p < .001, η_p^2 = .70**

	Tukey's post hocs: Same > New, Same > Similar (q = 10.28, 11.63, p < .001 all cases, respectively)
Scene component* Response type	$\boldsymbol{F_{(1.23,20.89)} = 37.05}$, **MSe = 3.07,** $\boldsymbol{p < .001, \eta_p^2 = .69}$
	Tukey's post hocs: For objects Same > Similar, Same > new, for backgrounds Same > Similar (Objects: q = 12.83, 13.85, p < .001 all cases, backgrounds: q = 3.61, p < .05)
Emotion* Response type	$F_{(4,68)} = 2.07$, MSe = 0.05, $p = .10$, $\eta_p^2 = .11$
Scene component* emotion* response type	$\boldsymbol{F_{(4,68)} = 3.40}$, **MSe = 0.08,** $\boldsymbol{p < .05, \eta_p^2 = .17}$
	For further analysis see planned contrasts.
Similar items	
Response type	$\boldsymbol{F_{(2,34)} = 9.55}$, **MSe = 1.25,** $\boldsymbol{p < .001, \eta_p^2 = .36}$
	Tukey's post hocs: Similar > Same, Same > New (q = 6.01, 4.25, p < .001, .05 respectively)
Scene component* Response type	$\boldsymbol{F_{(2,34)} = 15.12}$, **MSe = 1.44,** $\boldsymbol{p < .001, \eta_p^2 = .47}$
	Tukey's post hocs: For objects Similar > Same, New > Similar, for backgrounds New > Similar (Objects: q =5.17, 5.68, p < .01, .001, Backgrounds: q = 6.53, p < .001 respectively)
Emotion* Response type	$\boldsymbol{F_{(4,68)} = 3.00}$, **MSe = 0.09,** $\boldsymbol{p < .05, \eta_p^2 = .15}$
	For further analysis see planned contrasts.

Scene component* emotion* response type	$\boldsymbol{F_{(2.70,45.95)} = 2.66}$**, MSe = 0.09,** $\boldsymbol{p < .05, \eta_p^2 = .14}$
	For further analysis see planned contrasts.
New items	
Response type	$\boldsymbol{F_{(1.10,18.87)} = 260.80}$**, MSe = 19.89,** $\boldsymbol{p < .001, \eta_p^2 = .94}$
	Tukey's post hocs: New > Same, New > Similar, Similar > Same (q = 30.14, 25.13, 5.01, p < .001, .001, .01)
Scene component* Response type	$\boldsymbol{F_{(1.23,20.82)} = 4.54}$**, MSe = 0.10,** $\boldsymbol{p < .05, \eta_p^2 = .21}$
	Tukey's post hocs: For objects New > Same, New > Similar, for backgrounds New > Same, New > Similar, Similar > Same (Objects: q = 22.42, 19.34, p < .001; backgrounds: q = 20.20, 16.20, 4.00, p < .001, .001, .05 respectively)
Emotion* Response type	$F_{(2.32,39.36)} = 1.64$, MSe = 0.03, $p = .17$, $\eta_p^2 = .09$
Scene component* emotion* response type	$F_{(1.95,33.13)} = 0.59$, MSe = 0.01, $p = .67$, $\eta_p^2 = .03$

Table 5.1.2. Planned Contrasts

	Background		Object	
	Emotional vs. Neutral	Negative vs. Positive	Emotional vs. Neutral	Negative vs. Positive
SAME items				

Same response	Emo ≈ Neu $F_{(1,17)} = 2.32$, $p = .15$	Neg ≈ Pos $F_{(1,17)} = 4.38$, $p = .05$	**Emo > Neu** $\mathbf{F_{(1,17)} = 6.47}$, $\mathbf{p < .05}$	Neg ≈ Pos $F_{(1,17)} = 3.77$, $p = .07$
Similar response	Emo ≈ Neu $F_{(1,17)} = 2.25$, $p = .15$	Neg ≈ Pos $F_{(1,17)} = 0.29$, $p = .60$	Emo ≈ Neu $F_{(1,17)} = 2.91$, $p = .11$	Neg ≈ Pos $F_{(1,17)} = 4.25$, $p = .06$
New response	Emo ≈ Neu $F_{(1,17)} = 0.09$, $p = .93$	**Neg > Pos** $\mathbf{F_{(1,17)} = 5.13}$, $\mathbf{p < .05}$	Emo ≈ Neu $F_{(1,17)} = 3.55$, $p = .08$	Neg ≈ Pos $F_{(1,17)} = 0.19$, $p = .67$
SIMILAR items				
Same response	Emo ≈ Neu $F_{(1,17)} = 0.40$, $p = .54$	**Neg < Pos** $\mathbf{F_{(1,17)} = 7.46}$, $\mathbf{p < .05}$	**Emo > Neu** $\mathbf{F_{(1,17)} = 10.88}$, $\mathbf{p < .01}$	**Neg > Pos** $\mathbf{F_{(1,17)} = 5.39}$, $\mathbf{p < .05}$
Similar response	Emo ≈ Neu $F_{(1,17)} = 0.70$, $p = .42$	Neg ≈ Pos $F_{(1,17)} = 0.55$, $p = .47$	Emo ≈ Neu $F_{(1,17)} = 0.17$, $p = .69$	Neg ≈ Pos $F_{(1,17)} = 0.54$, $p = .47$
New response	Emo ≈ Neu $F_{(1,17)} = 2.22$, $p = .15$	Neg ≈ Pos $F_{(1,17)} = 1.15$, $p = .30$	**Emo > Neu** $\mathbf{F_{(1,17)} = 7.34}$, $\mathbf{p < .05}$	Neg ≈ Pos $F_{(1,17)} = 2.69$, $p = .12$
New items				
Same response	Emo ≈ Neu $F_{(1,17)} = 0.11$, $p = .75$	Neg ≈ Pos $F_{(1,17)} = 0.52$, $p = .48$	Emo ≈ Neu $F_{(1,17)} = 1.89$, $p = .19$	Neg ≈ Pos $F_{(1,17)} = 0.19$, $p = .67$
Similar response	Emo ≈ Neu $F_{(1,17)} = 0.95$,	Neg ≈ Pos $F_{(1,17)} = 0.37$,	Emo ≈ Neu $F_{(1,17)} = 0.04$,	Neg ≈ Pos $F_{(1,17)} = 4.25$,

	$p = .34$	$p = .55$	$p = .84$	$p = .06$
New response	Emo ≈ Neu $F_{(1,17)} = 0.83$, $p = .37$	Neg ≈ Pos $F_{(1,17)} = 0.06$, $p = .81$	Emo ≈ Neu $F_{(1,17)} = 0.27$, $p = .61$	Neg ≈ Pos $F_{(1,17)} = 2.99$, $p = .10$

Section 5.1.2 Analysis for Experiment 9

The influence of emotion and scene component on the responses given to *same*, *similar* and *new* items was analysed by conducting separate ANOVAs on each of the different types of items for each experiment. The results from the three 3 (emotion) x 2 (scene component) x 3 (response type) repeated measures ANOVAs are reported below in Tables 5.1.3 and 5.1.4.

In summary, the influence of emotion on memory for specific visual details was shown by the greater number of 'same' responses to *same* items for emotional than neutral objects. The central-peripheral trade-off was not significant in this experiment but the results are in the same direction as for other experiments. Although there was a significant interaction for the *new* items between emotion, scene component and response type, no emotional influences were apparent on responses to *new* items when planned contrasts were conducted; therefore, it appears that consistent with responses in the other experiments, there was no emotional influence on responses to items that had not been seen before.

Table 5.1.3. Results of ANOVAs on *Same*, *Similar* and *New* items

Same items

Effect	ANOVA result
Response type	$\boldsymbol{F_{(1.41,24.05)} = 39.34}$**, MSe = 6.84,** $\boldsymbol{p < .001, \eta_p^2 = .70}$
	Tukey's post hocs: Same > Similar, Same > New (q = 10.99, 10.73, p < .001 all cases, respectively)
Scene component* Response type	$\boldsymbol{F_{(2,34)} = 27.83}$**, MSe = 2.18,** $\boldsymbol{p < .001, \eta_p^2 = .62}$
	Tukey's post hocs: For objects Same > Similar, Same > New, for backgrounds Same > Similar (Objects: q = 10.97, 12.52, p < .001; Backgrounds: q = 4.57, p < .01)
Emotion* Response type	$F_{(4,68)} = 1.23$, MSe = 0.05, $p = .31$, $\eta_p^2 = .07$
Scene component* emotion* response type	$\boldsymbol{F_{(4,68)} = 3.93}$**, MSe = 0.12,** $\boldsymbol{p < .01, \eta_p^2 = .19}$
	For further analysis see Planned Contrasts.
Similar items	
Response type	$\boldsymbol{F_{(2,34)} = 7.52}$**, MSe = 1.10,** $\boldsymbol{p < .01, \eta_p^2 = .31}$
	Tukey's post hocs: Similar > Same (q = 5.44, p < .01)
Scene component* Response type	$\boldsymbol{F_{(2,34)} = 21.34}$**, MSe = 2.39,** $\boldsymbol{p < .001, \eta_p^2 = .56}$
	Tukey's post hocs: For objects Similar > Same, Similar > New, for backgrounds New > Same (Objects: q = 6.23, 8.05, p < .001 all cases;

	Backgrounds: $q = 4.80$, $p < .01$ respectively).
Emotion* Response type	$F_{(4,68)} = 1.56$, MSe = 0.04, $p = .20$, $\eta_p^2 = .08$
Scene component* emotion* response type	$\boldsymbol{F_{(4,68)} = 3.20}$, **MSe = 0.13,** $\boldsymbol{p < .02}$, $\boldsymbol{\eta_p^2 = .16}$
	See planned contrasts for further analysis
New items	
Response type	$\boldsymbol{F_{(1.16,19.69)} = 440.65}$, **MSe = 20.83,** $\boldsymbol{p < .001}$, $\boldsymbol{\eta_p^2 = .96}$
	Tukey's post hocs: New > Same, New > Similar, Similar > Same ($q = 38.61, 33.58, 5.03$, $p < .001, .001, .01$ respectively)
Scene component* Response type	$F_{(1.10,18.69)} = 2.42$, MSe = 0.06, $p = .10$, $\eta_p^2 = .12$
Emotion* Response type	$F_{(1.81,30.72)} = 0.28$, MSe = 0.01, $p = .89$, $\eta_p^2 = .02$
Scene component* emotion* response type	$\boldsymbol{F_{(2.52,42.85)} = 3.36}$, **MSe = 0.05,** $\boldsymbol{p < .05}$, $\boldsymbol{\eta_p^2 = .17}$
	See planned contrasts for further analysis

Table 5.1.4. Planned Contrasts

	Background		Object	
	Emotional vs. Neutral	Negative vs. Positive	Emotional vs. Neutral	Negative vs. Positive
SAME items				
Same response	Emo ≈ Neu $F_{(1,17)} = 0.04$,	Neg ≈ Pos $F_{(1,17)} = 1.87$,	**Emo > Neu** $\boldsymbol{F_{(1,17)} = 7.44}$**,**	Neg ≈ Pos $F_{(1,17)} = 2.91$,

	$p = .84$	$p = .19$	**$p < .05$**	$p = .11$
Similar response	Emo ≈ Neu $F_{(1,17)} = 1.24$, $p = .28$	Neg ≈ Pos $F_{(1,17)} = 0.79$, $p = .39$	Emo ≈ Neu $F_{(1,17)} = 2.38$, $p = .14$	Neg ≈ Pos $F_{(1,17)} = 4.04$, $p = .06$
New response	Emo ≈ Neu $F_{(1,17)} = 2.25$, $p = .15$	Neg ≈ Pos $F_{(1,17)} = 0.84$, $p = .37$	**Emo < Neu $F_{(1,17)} = 7.17$, $p < .05$**	Neg ≈ Pos $F_{(1,17)} = 0.11$, $p = .75$
SIMILAR items				
Same response	Emo ≈ Neu $F_{(1,17)} = 0.41$, $p = .53$	Neg ≈ Pos $F_{(1,17)} = 1.22$, $p = .28$	Emo ≈ Neu $F_{(1,17)} = 1.17$, $p = .29$	Neg ≈ Pos $F_{(1,17)} = 1.74$, $p = .21$
Similar response	**Emo < Neu $F_{(1,17)} = 6.11$, $p < .05$**	Neg ≈ Pos $F_{(1,17)} = 0.05$, $p = .82$	**Emo > Neu $F_{(1,17)} = 5.48$, $p < .05$**	Neg ≈ Pos $F_{(1,17)} = 2.46$, $p = .14$
New response	Emo ≈ Neu $F_{(1,17)} = 1.82$, $p = .20$	Neg ≈ Pos $F_{(1,17)} = 1.67$, $p = .21$	**Emo < Neu $F_{(1,17)} = 12.20$, $p < .01$**	Neg ≈ Pos $F_{(1,17)} = 0.56$, $p = .47$
New items				
Same response	Emo ≈ Neu $F_{(1,17)} < 0.00$, $p = 1.00$	Neg ≈ Pos $F_{(1,17)} = 2.96$, $p = .10$	Emo ≈ Neu $F_{(1,17)} = 0.63$, $p = .44$	Neg ≈ Pos $F_{(1,17)} = 0.32$, $p = .58$
Similar response	Emo ≈ Neu $F_{(1,17)} = 0.72$, $p = .41$	Neg ≈ Pos $F_{(1,17)} = 1.35$, $p = .26$	Emo ≈ Neu $F_{(1,17)} = 2.75$, $p = .12$	Neg > Pos $F_{(1,17)} = 4.00$, $p = .06$
New	Emo ≈ Neu	Neg ≈ Pos	Emo ≈ Neu	Neg ≈ Pos

response	$F_{(1,17)} = 0.95$, $p = .34$	$F_{(1,17)} = 0.25$, $p = .63$	$F_{(1,17)} = 0.97$, $p = .34$	$F_{(1,17)} = 2.70$, $p = .12$

Section 5.1.3 Analysis for Experiment 10

The influence of emotion and scene component on the responses given to *same*, *similar* and *new* items was analysed by conducting separate ANOVAs on each of the different types of items for each experiment. The results from the three 3 (emotion) x 2 (scene component) x 3 (response type) repeated measures ANOVAs are reported below in Tables 5.1.5 and 5.1.6.

In summary, the emotional influence on memory for specific visual details was apparent in the greater number of 'same' responses to *same* items for emotional than neutral objects. The central-peripheral trade-off was not significant in this experiment but, as described above, the pattern of results was the same as for the other experiments. There was no indication of any emotional influence on responding to items in the absence of recognition, as evidenced by lack of any emotional effects on responses to *new* items.

Table 5.1.5. Results of ANOVAs on *Same*, *Similar* and *New* items

Same items	
Effect	ANOVA result
Response type	$\mathbf{F_{(2,34)} = 36.35}$, **MSe = 4.56,** $\mathbf{p < .001}$, $\boldsymbol{\eta_p^2} = \mathbf{.68}$
	Tukey's post hocs: Same > Similar, Same > New ($q = 11.17, 9.51$, $p < .001$ all cases, respectively)
Scene component* Response type	$\mathbf{F_{(2,34)} = 32.74}$, **MSe = 2.16,** $\mathbf{p < .001}$, $\boldsymbol{\eta_p^2} = \mathbf{.66}$

	Tukey's post hocs: For objects Same > Similar, Same > New, for backgrounds Same > Similar (Objects: q = 11.53, 12.54, p < .001; Backgrounds q = 4.28, p < .05)
Emotion* Response type	$F_{(4,68)}$ = 2.30, MSe = 0.08, p = .07, η_p^2 = .12
Scene component* emotion* response type	**$F_{(4,68)}$ = 9.16, MSe = 0.24, p < .001, η_p^2 = .35**
	For further analysis see planned contrasts
Similar items	
Response type	**$F_{(2,34)}$ = 3.84, MSe = 0.52, p < .05, η_p^2 = .18**
	Tukey's post hocs: Similar > Same (q = 3.91, p < .05)
Scene component* Response type	**$F_{(2,34)}$ = 28.79, MSe = 1.55, p < .001, η_p^2 = .63**
	Tukey's post hocs: For objects Similar > Same, Similar > New, for backgrounds New > Same (Objects: q = 3.76, 6.13, p < .05, .001; backgrounds q = 4.78, p < .01)
Emotion* Response type	$F_{(4,68)}$ = 2.38, MSe = 0.10, p = .06, η_p^2 = .12
Scene component* emotion* response type	$F_{(4,68)}$ = 1.92, MSe = 0.09, p = .12, η_p^2 = .10
New items	
Response type	**$F_{(1.34,22.75)}$ = 332.39, MSe = 20.67, p < .001, η_p^2 = .95**
	Tukey's post hocs: New > Same, New > Similar,

	Similar > Same (q = 33.33, 29.47, 3.86, p < .001, .001, .05 respectively)
Scene component* Response type	$F_{(2,34)}$ = 0.57, MSe = 0.02, p = .57, η_p^2 = .03
Emotion* Response type	$F_{(2.25,38.25)}$ = 0.82, MSe = 0.02, p = .52, η_p^2 = .05
Scene component* emotion* response type	$F_{(2.34,39.86)}$ = 1.42, MSe = 0.02, p = .24, η_p^2 = .08

Table 5.1.6. Planned Contrasts

	Background		Object	
	Emotional vs. Neutral	Negative vs. Positive	Emotional vs. Neutral	Negative vs. Positive
		SAME items		
Same response	Emo ≈ Neu $F_{(1,17)}$ = 2.37, p = .14	Neg ≈ Pos $F_{(1,17)}$ = 2.59, p = .13	**Emo > Neu $F_{(1,17)}$ = 19.47, p < .001**	Neg ≈ Pos $F_{(1,17)}$ = 2.74, p = .12
Similar response	Emo ≈ Neu $F_{(1,17)}$ = 0.21, p = .65	Neg ≈ Pos $F_{(1,17)}$ = 0.46, p = .51	**Emo < Neu $F_{(1,17)}$ = 6.75, p < .05**	**Neg < Pos $F_{(1,17)}$ = 4.62, p < .05**
New response	Emo ≈ Neu $F_{(1,17)}$ = 3.85, p = .07	**Neg > Pos $F_{(1,17)}$ = 5.82, p < .05**	**Emo < Neu $F_{(1,17)}$ = 8.19, p < .05**	Neg ≈ Pos $F_{(1,17)}$ < 0.01, p = 1.00
		SIMILAR items		
Same	Emo ≈ Neu	Neg ≈ Pos	Emo ≈ Neu	Neg ≈ Pos

response	$F_{(1,17)} = 1.95$, $p = .18$	$F_{(1,17)} = 0.08$, $p = .78$	$F_{(1,17)} = 1.80$, $p = .20$	$F_{(1,17)} = 1.67$, $p = .21$
Similar response	Emo < Neu $F_{(1,17)} = 1.26$, $p = .28$	Neg ≈ Pos $F_{(1,17)} < 0.00$, $p = 1.00$	**Emo > Neu** $\boldsymbol{F_{(1,17)} = 8.70}$, $\boldsymbol{p < .01}$	Neg ≈ Pos $F_{(1,17)} = 0.79$, $p = .39$
New response	Emo ≈ Neu $F_{(1,17)} = 0.02$, $p = .90$	Neg ≈ Pos $F_{(1,17)} = 0.05$, $p = .83$	**Emo < Neu** $\boldsymbol{F_{(1,17)} = 11.96}$, $\boldsymbol{p < .01}$	Neg ≈ Pos $F_{(1,17)} = 0.03$, $p = .87$
New items				
Same response	Emo ≈ Neu $F_{(1,17)} = 0.23$, $p = .64$	Neg ≈ Pos $F_{(1,17)} = 1.36$, $p = .26$	Emo ≈ Neu $F_{(1,17)} = 1.80$, $p = .20$	Neg ≈ Pos $F_{(1,17)} = 3.40$, $p = .08$
Similar response	Emo ≈ Neu $F_{(1,17)} = 0.14$, $p = .71$	Neg ≈ Pos $F_{(1,17)} = 3.77$, $p = .07$	Emo ≈ Neu $F_{(1,17)} = 0.53$, $p = .48$	Neg > Pos $F_{(1,17)} = 0.17$, $p = .68$
New response	Emo ≈ Neu $F_{(1,17)} = 0.33$, $p = .57$	Neg ≈ Pos $F_{(1,17)} = 1.05$, $p = .32$	Emo ≈ Neu $F_{(1,17)} = 2.07$, $p = .17$	Neg > Pos $F_{(1,17)} = 0.04$, $p = .85$

Appendix 5.2. Analysis of Variance in Ratings of Encoding Task for Experiments 9 and 10

The variance in ratings for the encoding task for Experiments 9 and 10 was analysed by calculated the standard deviation in ratings given by each participant for scenes with a negative, neutral or positive object. This revealed a greater degree of variance in the ratings given in Experiment 9 where the scenes were blocked into those of the same emotion, compared to the ratings given in Experiment 10 when the scenes were presented in a pseudorandomised order (See Table 5.1.7). Participants were given a cue as to the emotion of the next scenes in each Experiment, although in Experiment 9 this was only indicated at the start of each block, whereas in Experiment 10 this was indicated before each item. Paired samples t-tests were used to statistically compare these values between Experiments. This revealed no statistically significant difference between the values for Experiment 9 and 10 (Negative: $t(34) = 1.07$, $p = .29$; Neutral: $t(34) = 1.37$, $p = .18$; Positive $t(34) = 1.35$, $p = .19$).

Table 5.1.7. Average standard deviations for ratings of approach / avoidance in encoding task for Experiments 9 and 10

	Experiment 9	Experiment 10
Negative	1.31	1.16
Neutral	1.12	0.95
Positive	1.23	1.05